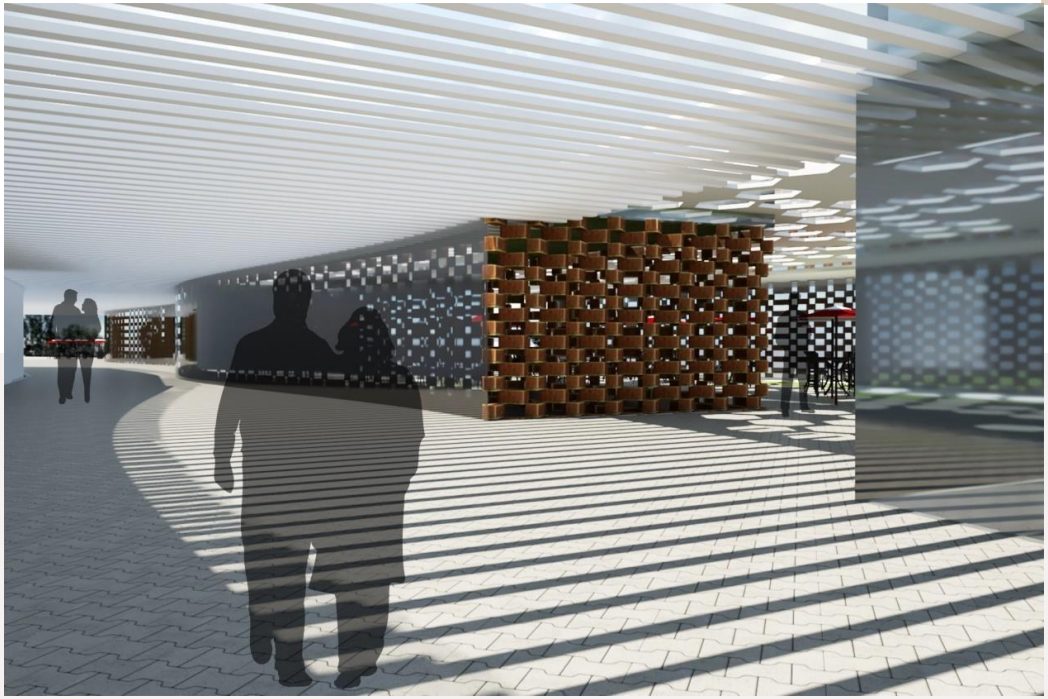
U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

Pottery Retail Hub

Typology - Retail Building (RT) I SPARC



SATHYABAMA INSTITUTE OF SCIENCE & TECHNOLOGY I CHENNAI I INDIA

Design Presentation

TEAM

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Rakesh Kumar
Shalini

OUR SUPPORT

U.S DEPARTMENT OF ENERGY – Solar Decathlon, 2021

- Dean, SIST
  - Arkip Stelin

  - Clintia Karen

- Faculty Advisor, SIST
  - Priyanga

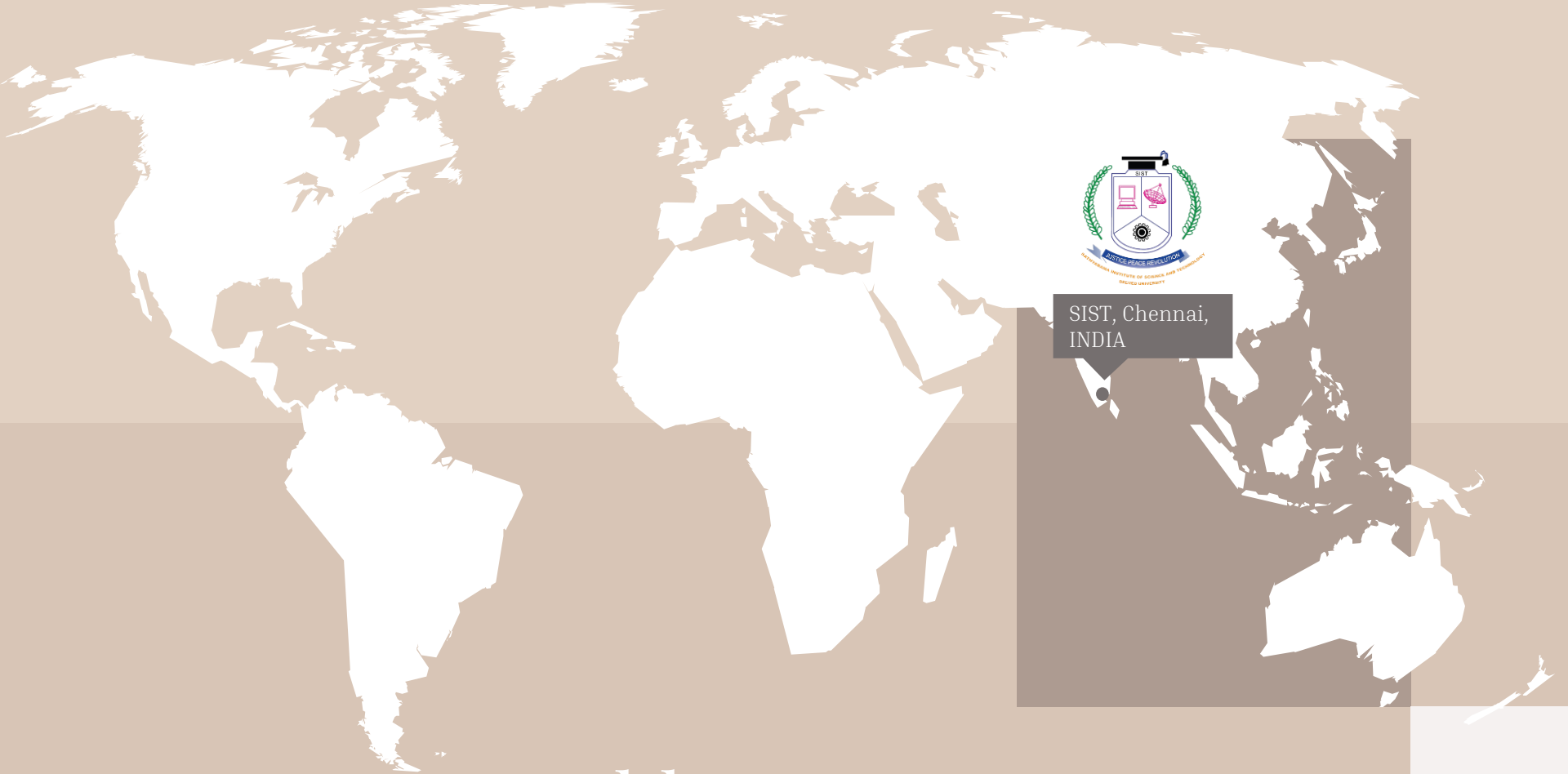
  - Rakesh Kumar

  - Shalini

Save pottery !

Being Creative is not a hobby.

It's the way of life

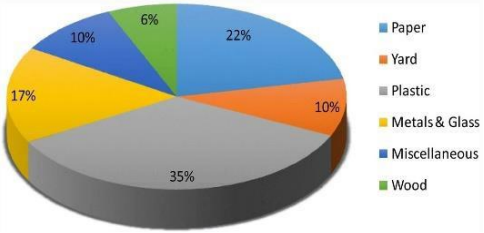


World Map

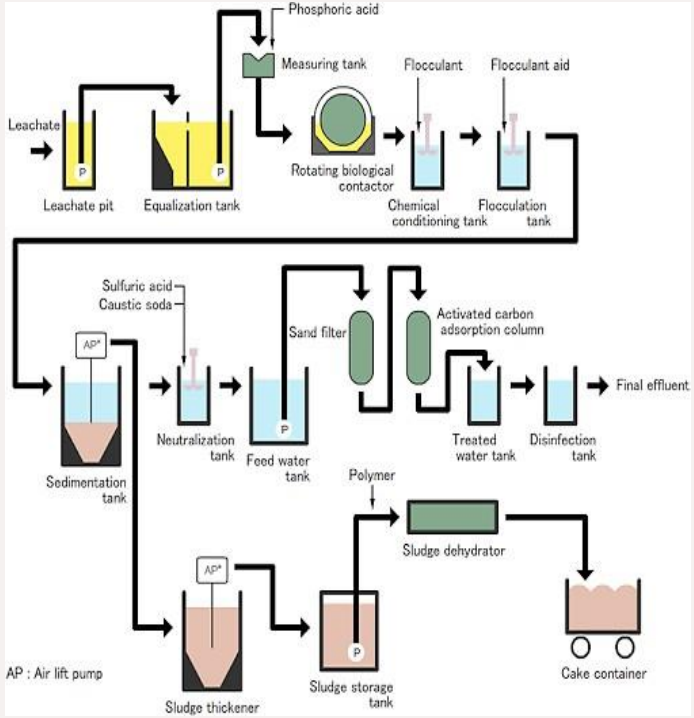
History and Reasoning for the topic

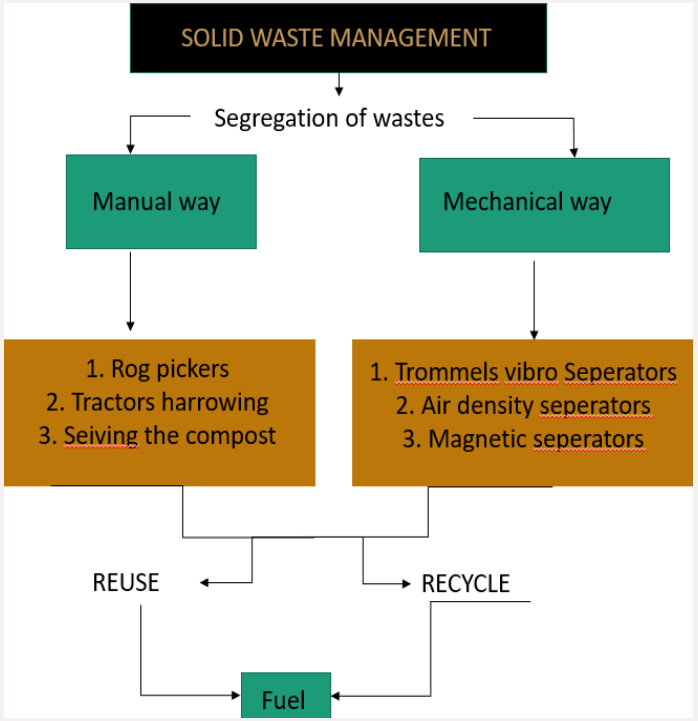
Brownfield Site - Landfill Site

Bio Mining Process

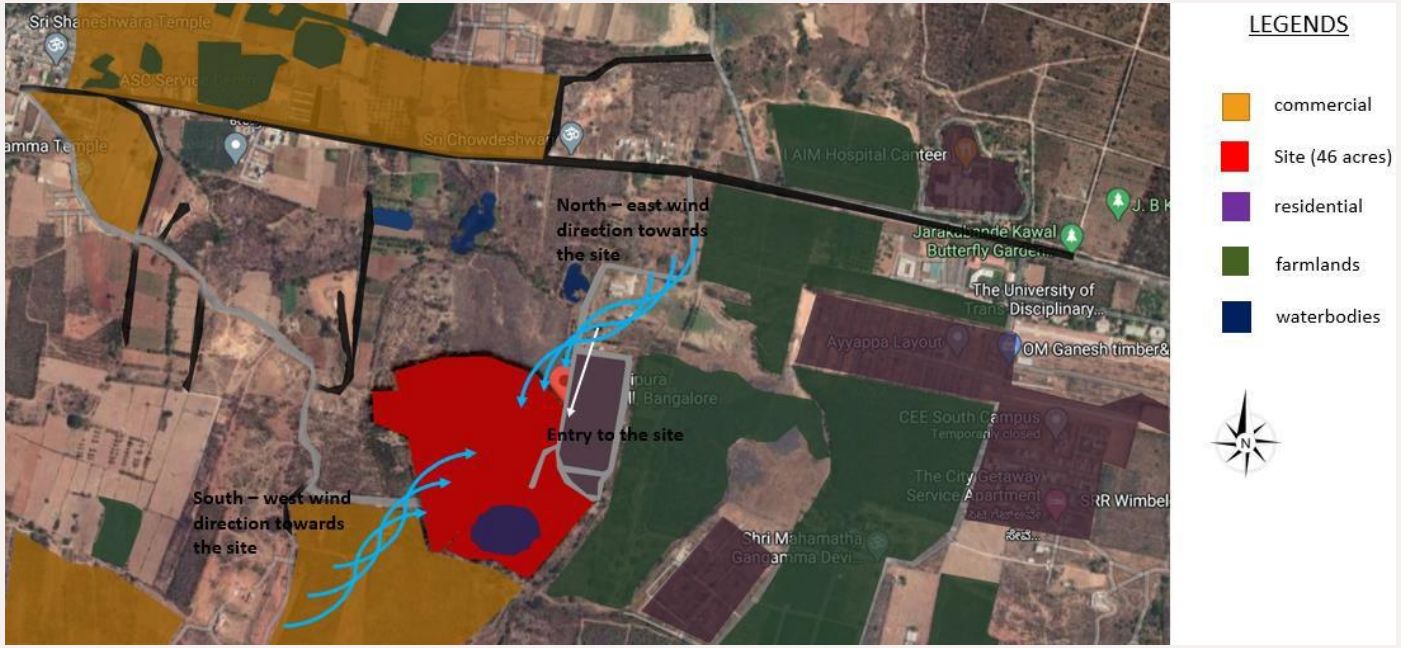


Component	Percentage (wt.%)
Organic materials	40
Unrecyclable Plastics	10
Unrecyclable materials	30
Agriculture waste	20
Total	100



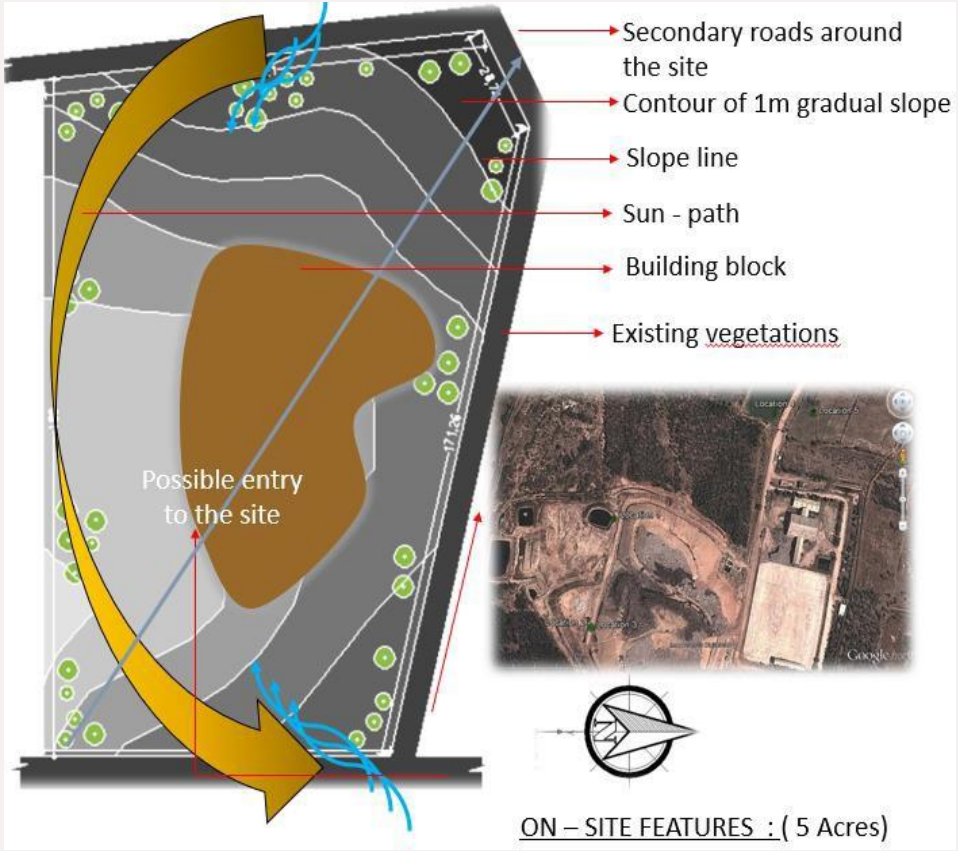


Site Analysis and Land use



Onsite & Offsite Features

Slope & Climate Analysis



SWOT Analysis &
Current State of the site

STRENGTH:

- Sustainable site
- Flat land for pottery craft is advisable
- Climate of the site
- Adjacent to 9m wide road

WEAKNESS:

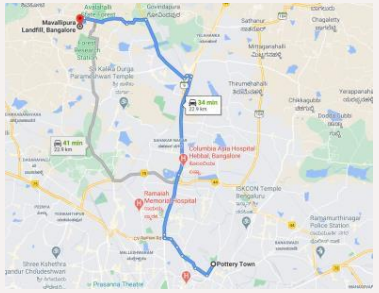
- Location is abandoned
- Linkage between core zone and site

OPPORTUNITY:

- Development of landfill site
- Resettlement of pottery village
- To re-design a sustainable site

THREAT:

- Ground water contamination
- Air pollution



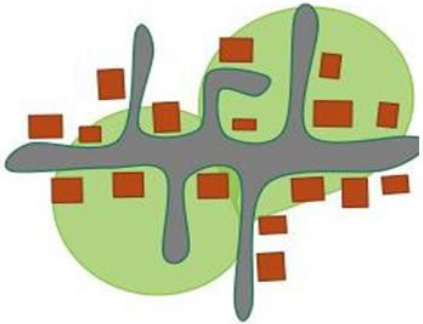
Soil Type & it's Construction

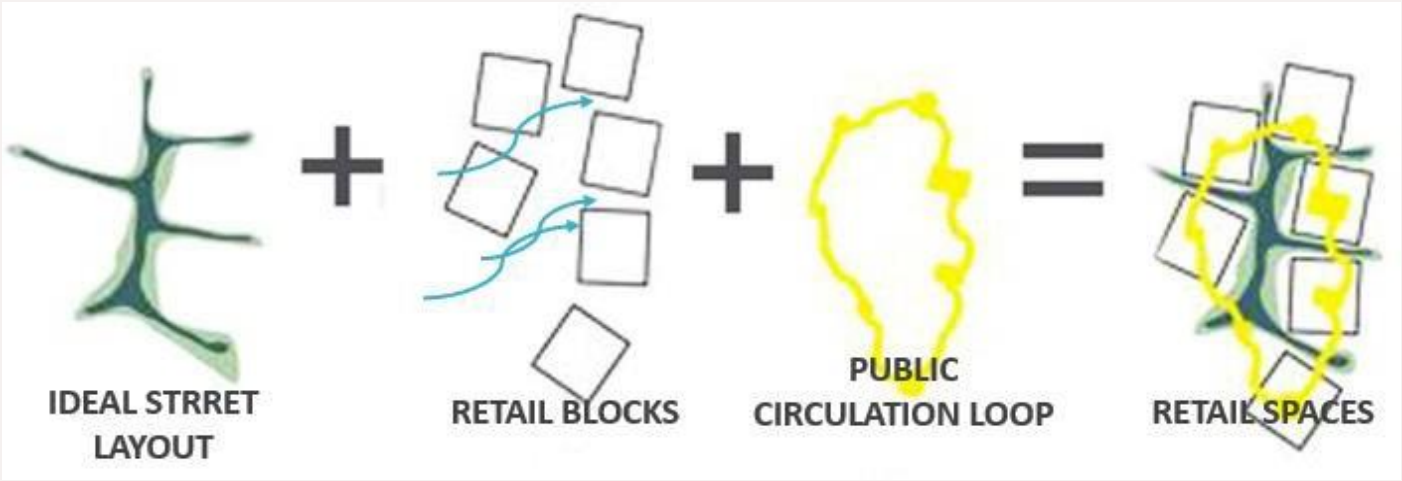
SLAB FOUNDATION

Advantages

- Price: Generally, slab foundations are your cheapest option when it comes to foundations, an excellent choice if budget is front-of-mind.
- Low Maintenance: Of all foundation-types, slabs require the least amount of maintenance, adding to their pricing value.

Street morphology



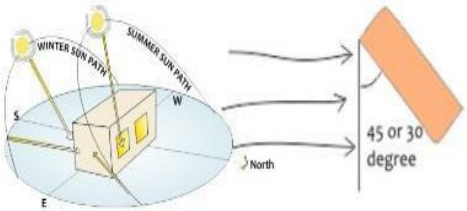


Smaller connecting streets to serve as secondary pathways to connect to the adjoining spaces.

Pottery retail space with the shops and stores to follow the concept of street morphology to maintain the ideology of traditional retail space of the pottery artisans.

The main idea is to provide them with a space with the feel of their original habitat as they should not feel disconnected or separated about the new space.

Low rise planning



The aim objective of designing the retail hub for the artisans community of Bangalore is to maintain the originality of their habitat through space planning.

- Low rise scattered zoning is followed to imitate the visual appeal of their traditional space.
- To create a more interactive space to increase the social sustainability.
- To facilitate more passive strategies in the design.

Natural Lighting & ventilation ideology

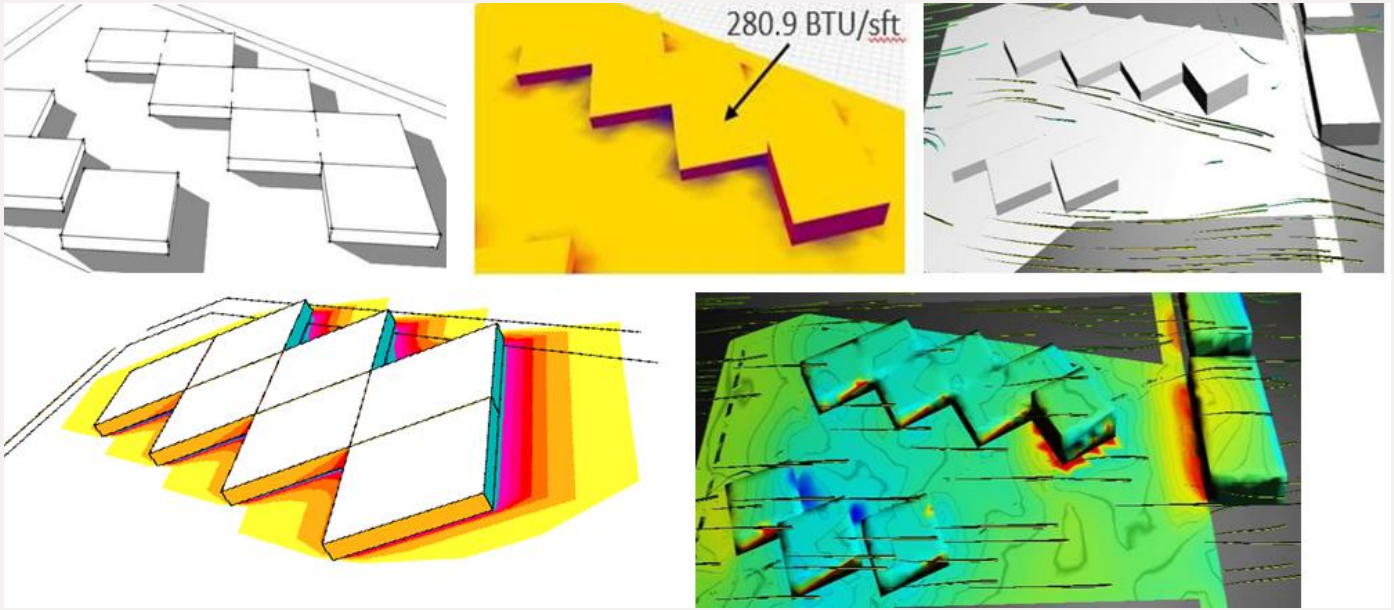
Indirect and Direct Natural Lighting is one of the main requirements for pottery retail spaces. To showcase their products and and also to avoid glare at certain areas.

Pergolas & Jali walls to induce natural lighting to the indoor space avoiding the solar heat gain.

Louvered Walls or Partitions. This will help in allowing the daylight when required. The heat gain can also be controlled by placing the louvres in suitable angles. Glazing Facades to allow natural light indoor during the day.

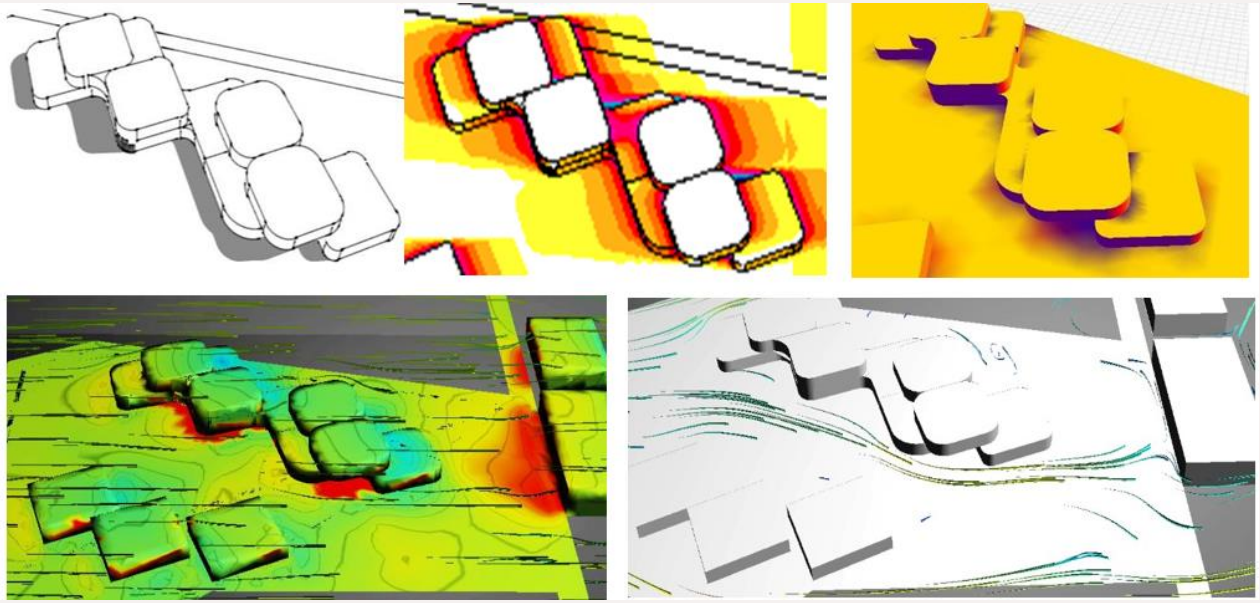
To lit up the surrounding outdoor space with the indoor artificial lighting during night.

Form iteration-1



The roof is exposed to maximum radiations throughout the day. The blocks remain shaded due to the 45deg orientation. The block occupies more space hence the circulation space gets reduced and the site is congested. Very less air velocity is noted throughout the site and no uniform distribution is noted.

Form iteration-2

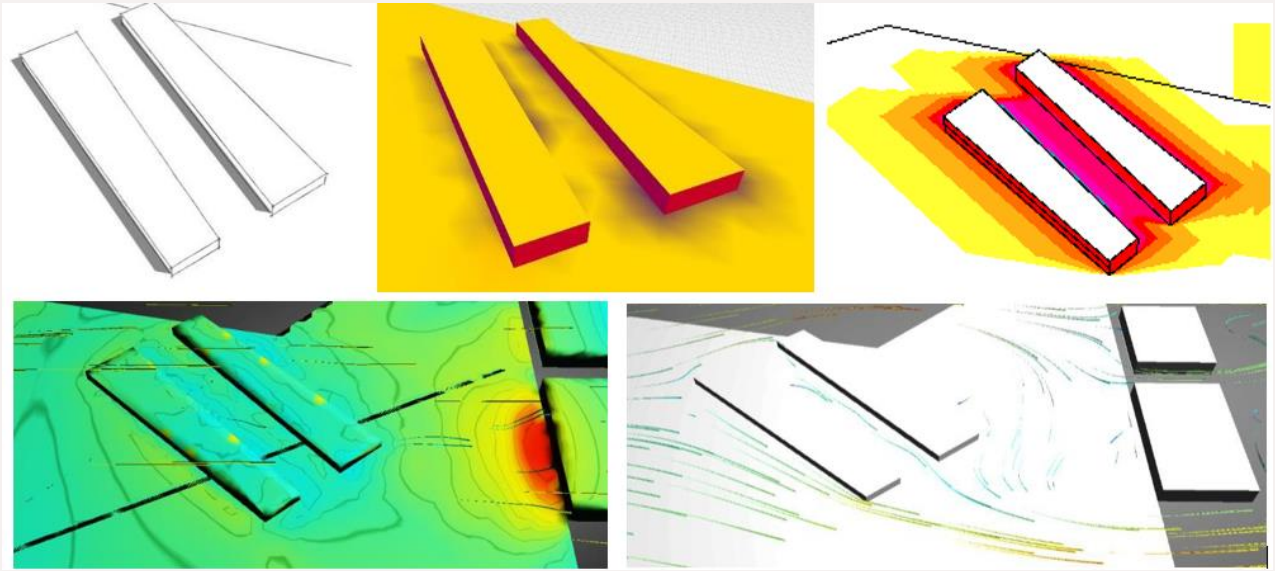


The blocks with curved edges creates more shade in the adjacent spaces thereby creating self shading .

Increase in wind pressure is noted throughout the site. The curved edges facilitate uniform air flow to all corners of the block.

Direct radiation in the southern and western facades is greatly reduced and the roof also experiences lesser radiations at certain points.

Form iteration-3

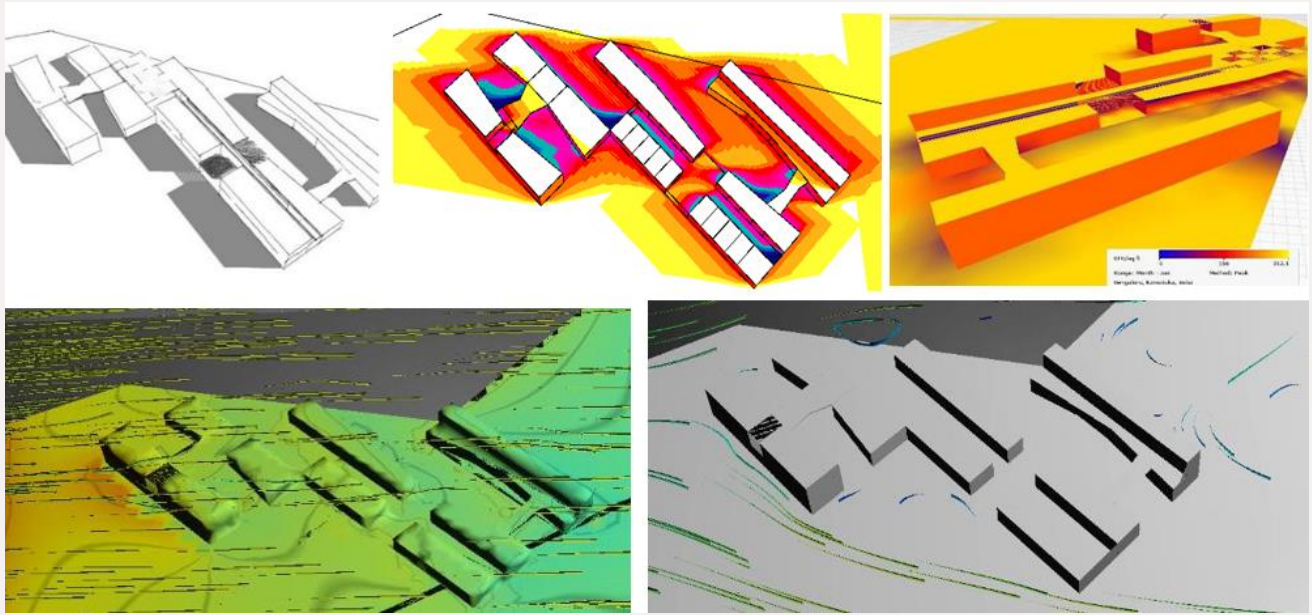


The single block when split into two blocks creates shading to the in between circulation spaces.

Direct solar radiation in the space between the blocks is greatly reduced during the peak seasons due to the shade casted by the adjacent blocks.

The roof is still exposed to maximum solar heat gain. Circulation of air in between the blocks is noted, this also increases the air velocity in the surrounding areas of the site. The wind speed is 8m/s.

Form iteration-4

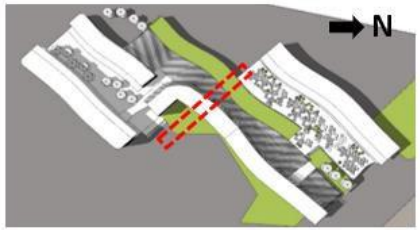


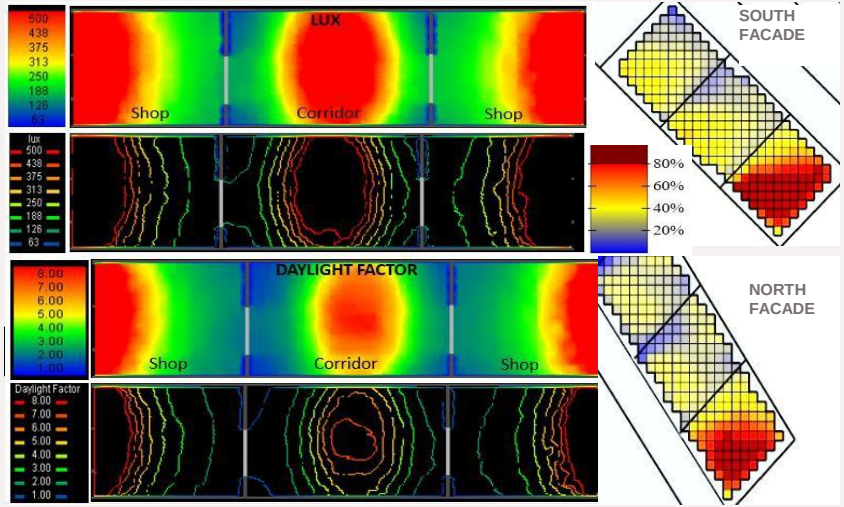
Form casts larger shadow during the peak hours of the day creating mutual shading with the adjacent blocks.

Angled form reduces the spaces exposed to direct solar radiation during the peak hours of the day without the usage of shading devices.

Uniform and equal distribution of wind is noted throughout the site. All facades of the block receives wind through cross ventilation. Air pressure is also equally distributed.

Daylight analysis





UDI - Useful Daylight Illuminance

TABLE 2- Calculation for Daylight Area Meeting UDI Requirement

ORIENTATION	DEF	HEAD HEIGHT (m)	FENESTRATION WIDTH	X m (distance Perpendicular To fenestration)	Y m (distance Parallel To fenestration)	X * Y (m2)Above grade area meeting the UDI requirement for 90% of the time in an year
North	2.8	4	595	11.2	597	1268.5
South	2.3	4	595	9.2	597	1059.87
East	1.5	4	86.4	6	88.4	530.4
West	1.1	4	86.4	4.4	88.4	388.96
Total daylight area per floor meeting UDI requirement during 20% of the year						3241.73

(with the ref. of table 4-1 Daylight Requirement - Pg.no. - 21)

3241.73 m2 of area will meet the UDI requirements. This is 67.3 % of the total above grade floor area of 4838.4 m2. Thus, the building will comply with UDI requirement.

(with the ref. of table 4-1 Daylight Requirement - Pg.no. - 21 - REQUIRED - 20% & above)

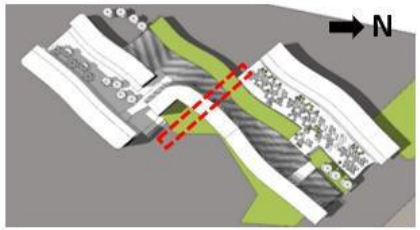
Maximum Lux of 500 and DF OF 8 is noted is achieved to almost 60% of the indoor space and then decreases to about 180 lux and DF of 3.

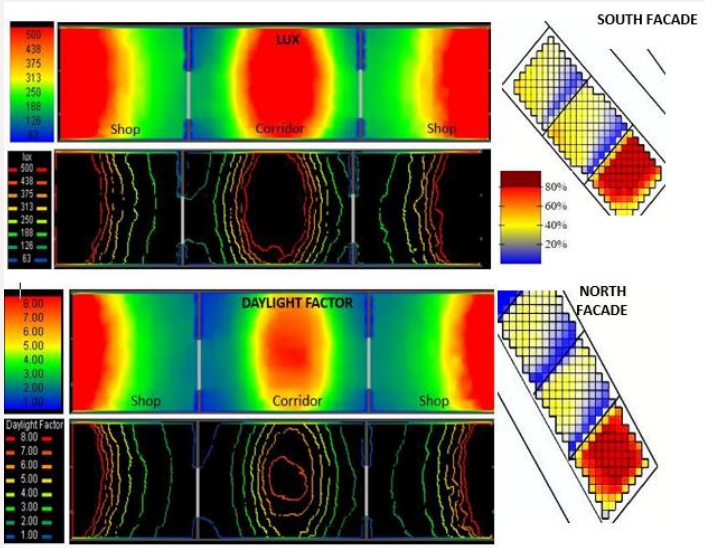
This is noted for the month of June.

Percentage of daylight received by the indoor spaces of the shops in the northern and southern façade is min of 30% in all areas.

Corner shops receive UDI of 67.3% is achieved for the proposed case of total area 2833 sq.m hence it has achieved the min required percentage 20% as per ECBC.

Daylight analysis





Maximum Lux of 500 and DF OF 8 is noted is achieved to almost 60% of the indoor space and then decreases to about 180 lux and DF of 3.

This is noted for the month of December.

Percentage of daylight received by the indoor spaces **in the northern and southern** façade is **above 40%** to almost 80% of the indoor space.

Corner shops receive **above 60%** daylight as they receive light from east also.

S.No.	TABLE 1 - WINDOW - WALL RATIO			TOTAL
1	Total Fenestration Area (JAALI - 2:1)	(North, South, East)	1259.8	
2	Total Fenestration Area (JAALI - 2:0.5)	(West)	86.4	1346.2
3	Total Wall Area	(North, South, East)	3779.4	
4	Total Wall Area	(West)	216	3995.4
	WINDOW - WALL RATIO			0.336937478
				30%

Ref. : 4.3.3 - Vertical Fenestration - Maximum allowable Window Wall Ratio (WWR) is 40% (applicable to buildings showing compliance using the Prescriptive Method, including Building Envelope Trade-off Method)

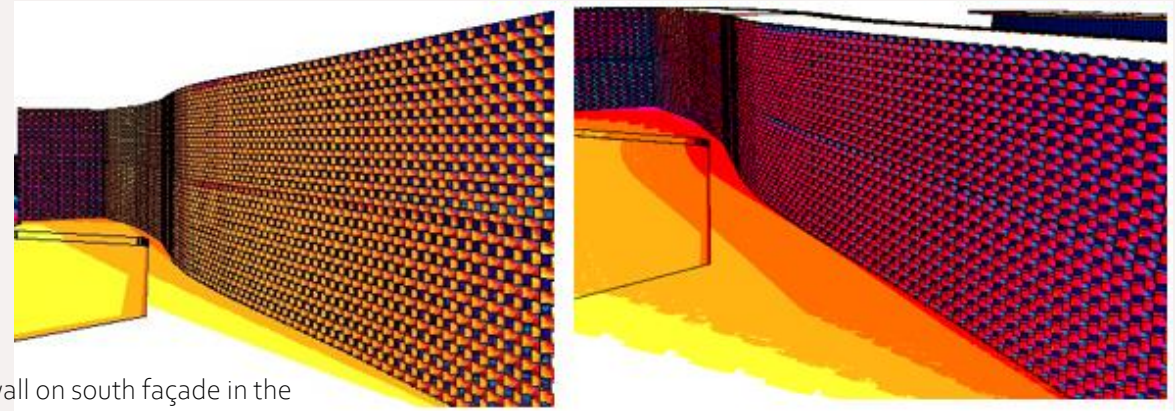
ECBC REFERENCE

Table 4-1 Daylight Requirement

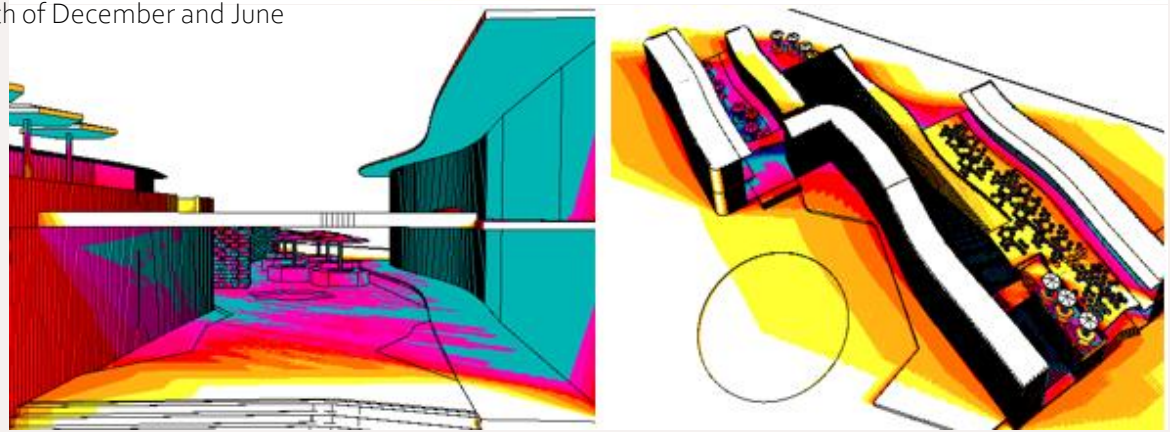
Building Category	Percentage of above grade floor area meeting the UDI requirement		
	ECBC	ECBC+	SuperECBC
Business, Educational	40%	50%	60%
No Star Hotel Star Hotel Healthcare	30%	40%	50%
Resort	45%	55%	65%
Shopping Complex	10%	15%	20%
Assembly*	Exempted		

*and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area

Shadow analysis



Jali wall on south façade in the month of December and June

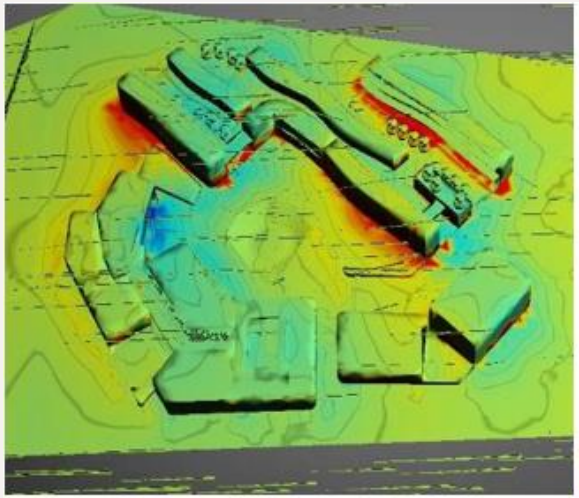


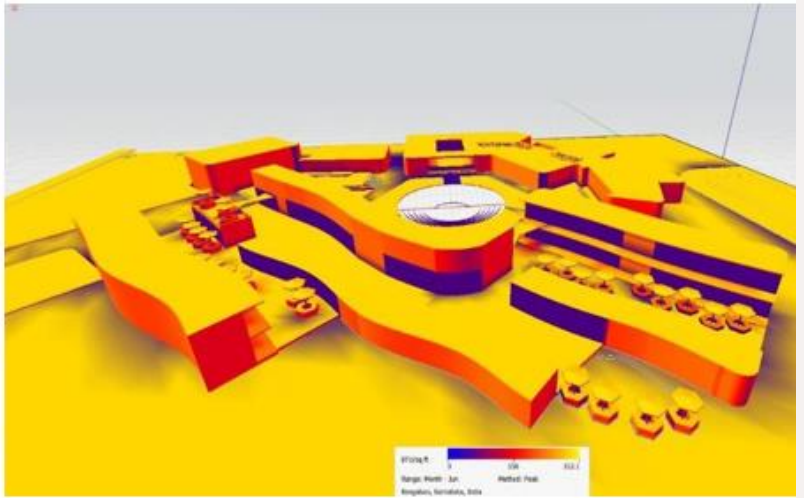
Circulation and plaza spaces are covered using pergolas as they provide shade to the pedestrian movement spaces.

Site Plan – 5 Acres

Entry to the retail block is a wide semi covered plaza space of 8m wide to enhance the circulation movement and access to the shops on either side depicting the street concept.

Site Analysis –
Solar Radition



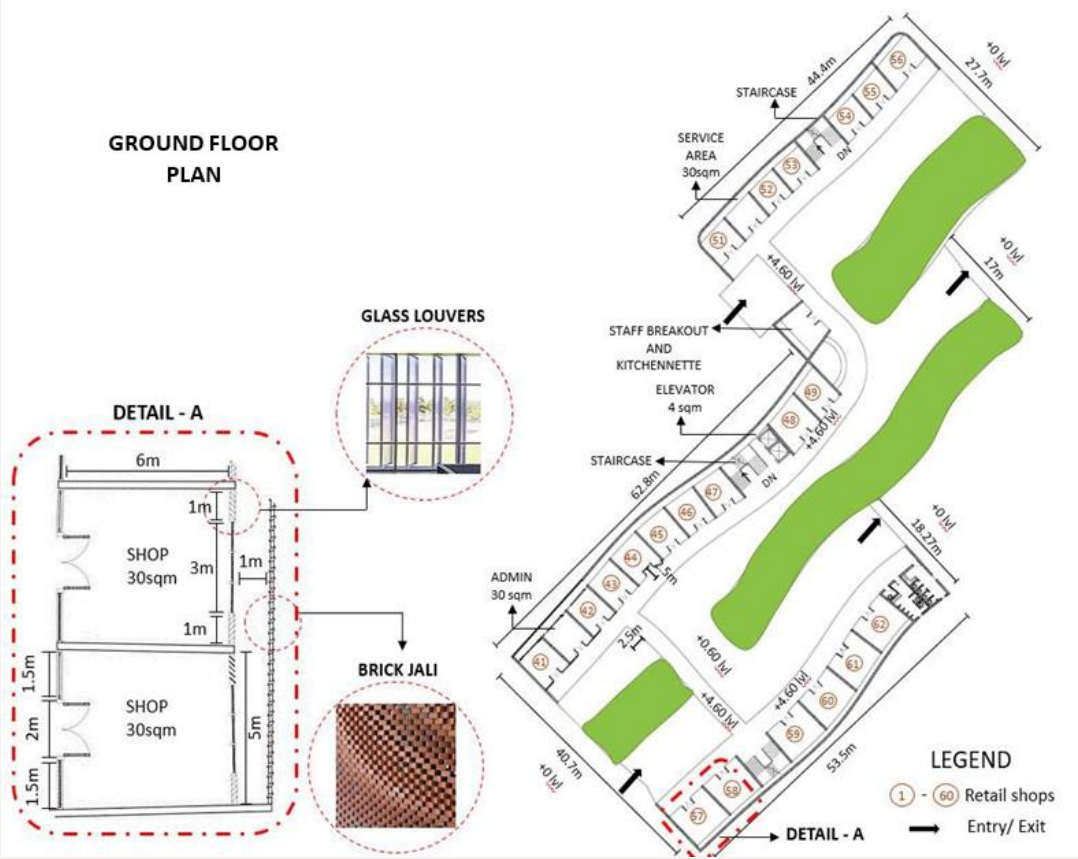


Direct solar radiation is reduced in the site area due to the placement of blocks creating mutual shading.

The radiation on the rooftop is mitigated using materials with low U value.

Uniform wind pressure is noticed throughout the site due to the 45 deg angled placement of blocks.

Retail Space



Entry to the retail block is a wide semi covered plaza space of 8m wide to enhance the circulation movement and access to the shops on either side depicting the street concept.

Pergolas along the corridor space in the ratio 1:2 to reduce the direct solar radiation also by allowing sufficient daylight inside the space.

Retail Space

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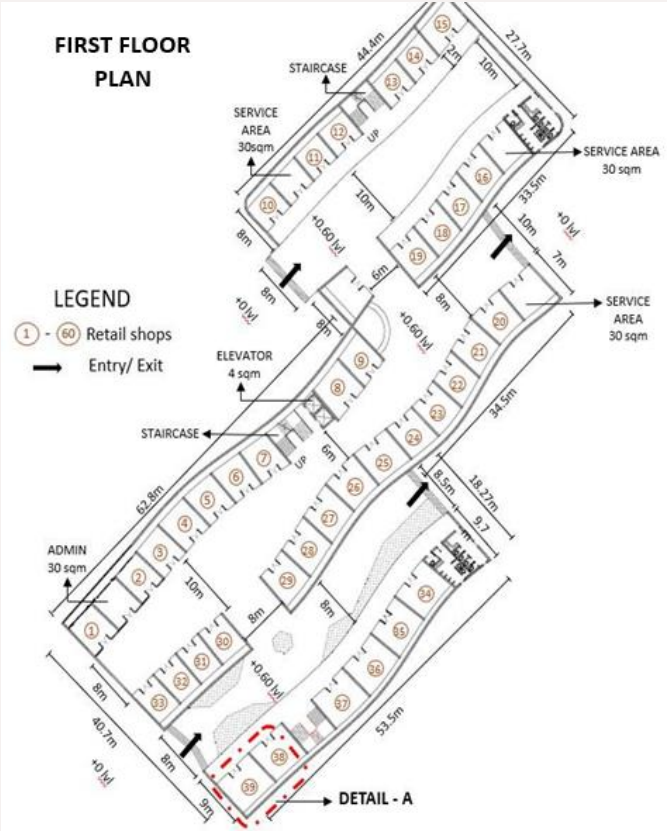
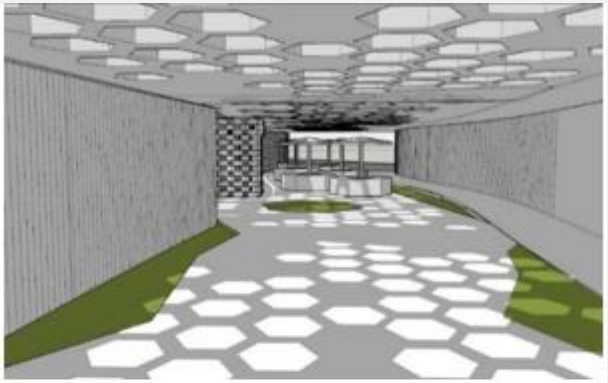
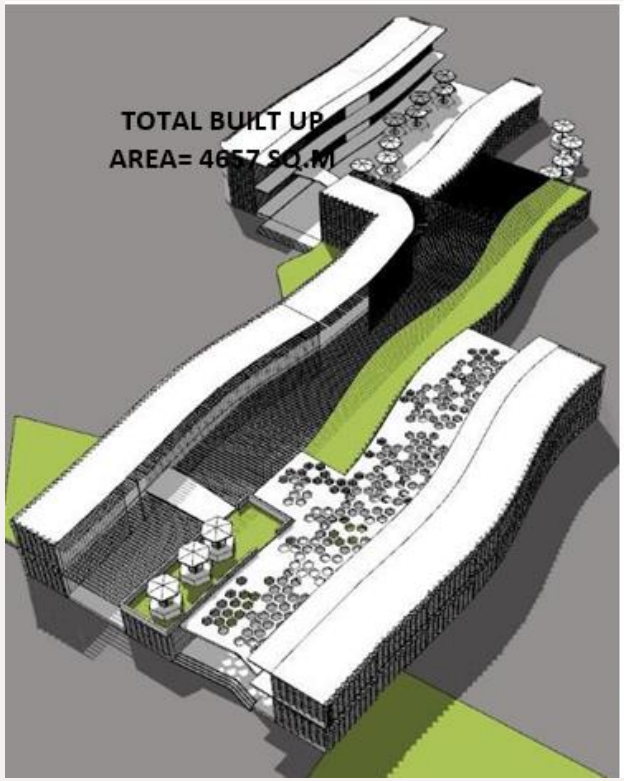


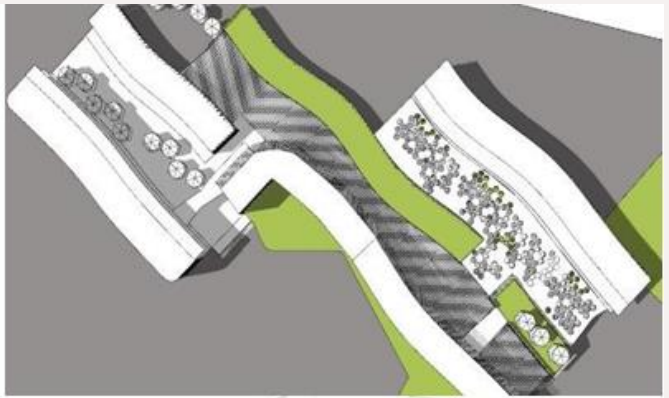


Retail Space

Connecting corridors between blocks in 1st floor are shaded bridges also opening into the seating area in the green roof.

Greens roofs are provided for the single story blocks.





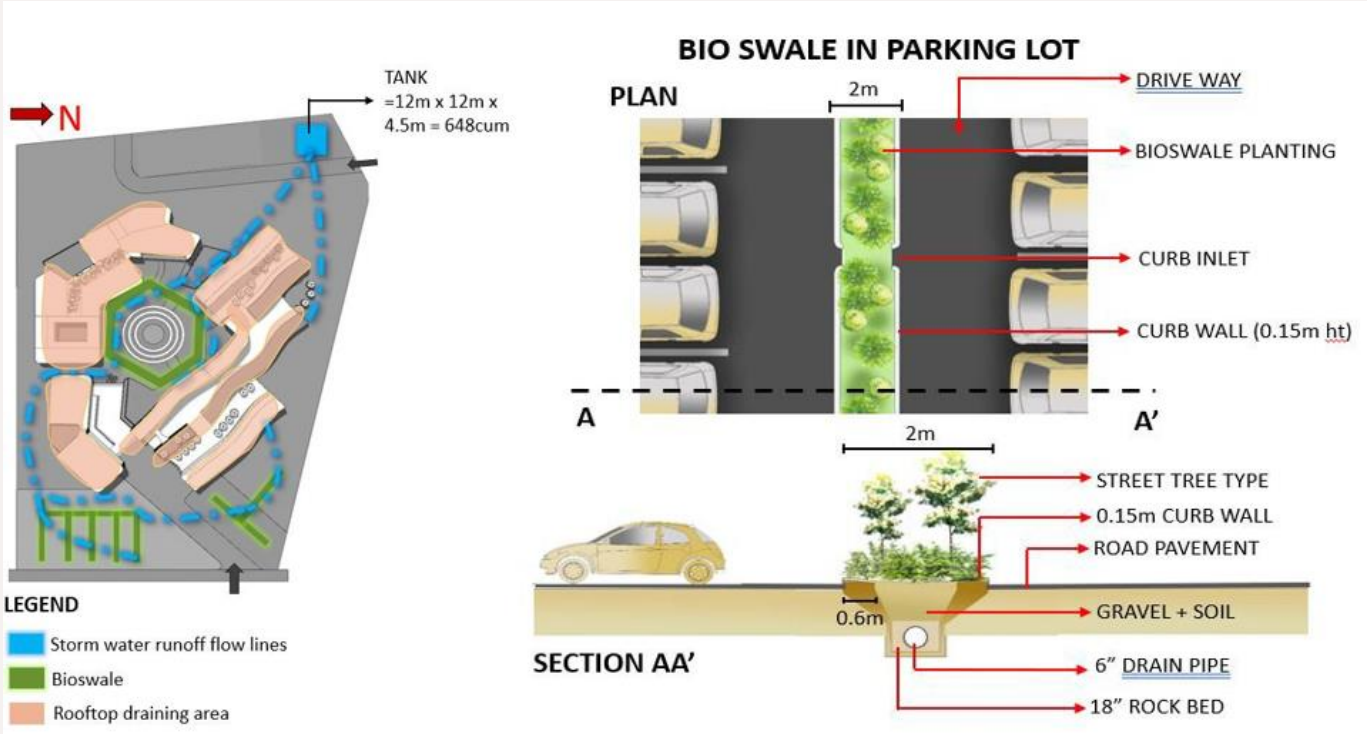
STORM WATER COLLECTION

Total collected liters from pavements = 93,400 liters

Total collected water = 5,80,236 liters

TANK CAPACITY - 12mx12mx4.5m = 648cum x

1000litres = 6,48,000 liters



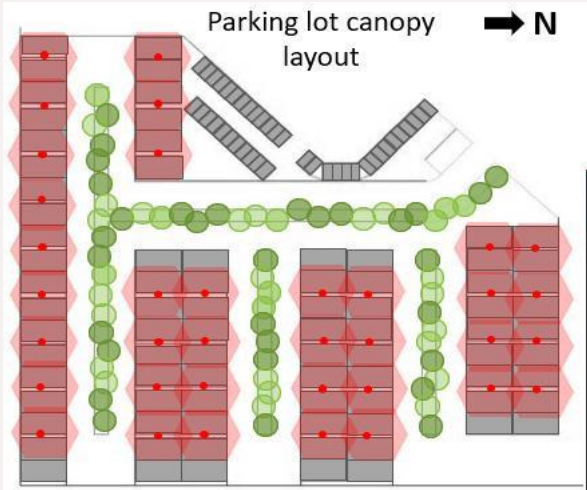
Inverted Canopies – Potable Water Calculation

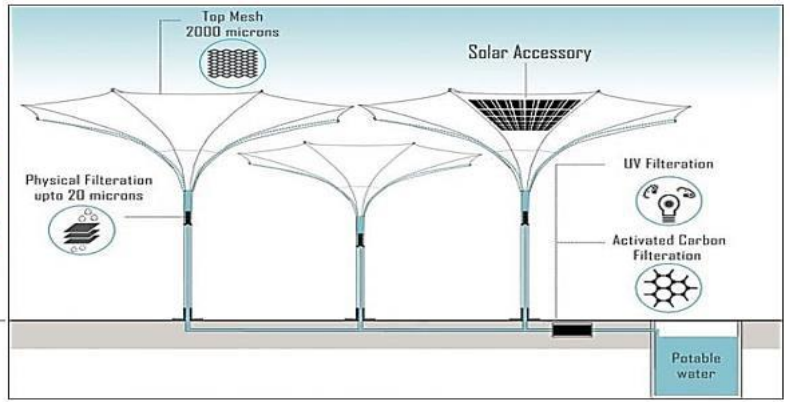
Total No of Parking Lot Canopies = 52 no.s CANOPY SIZE – 5m x 5m = 25 sq.m CANOPY HEIGHT – 3.2m

STRUCTURE – 75mm Underground Piping

100mm concrete slab for anchor fasteners

FILTRATION TECHNOLOGY – Multi layered filtration system





WATER QUALITY – Below 10 NTU (turbidity unit). Meets WHO standards for potable water.

POWER CAPACITY – 35KWH annually.

15 watts per sq.ft.

HARVESTING CAPACITY – 50,000-1,08,000 liters capacity per canopy annually.

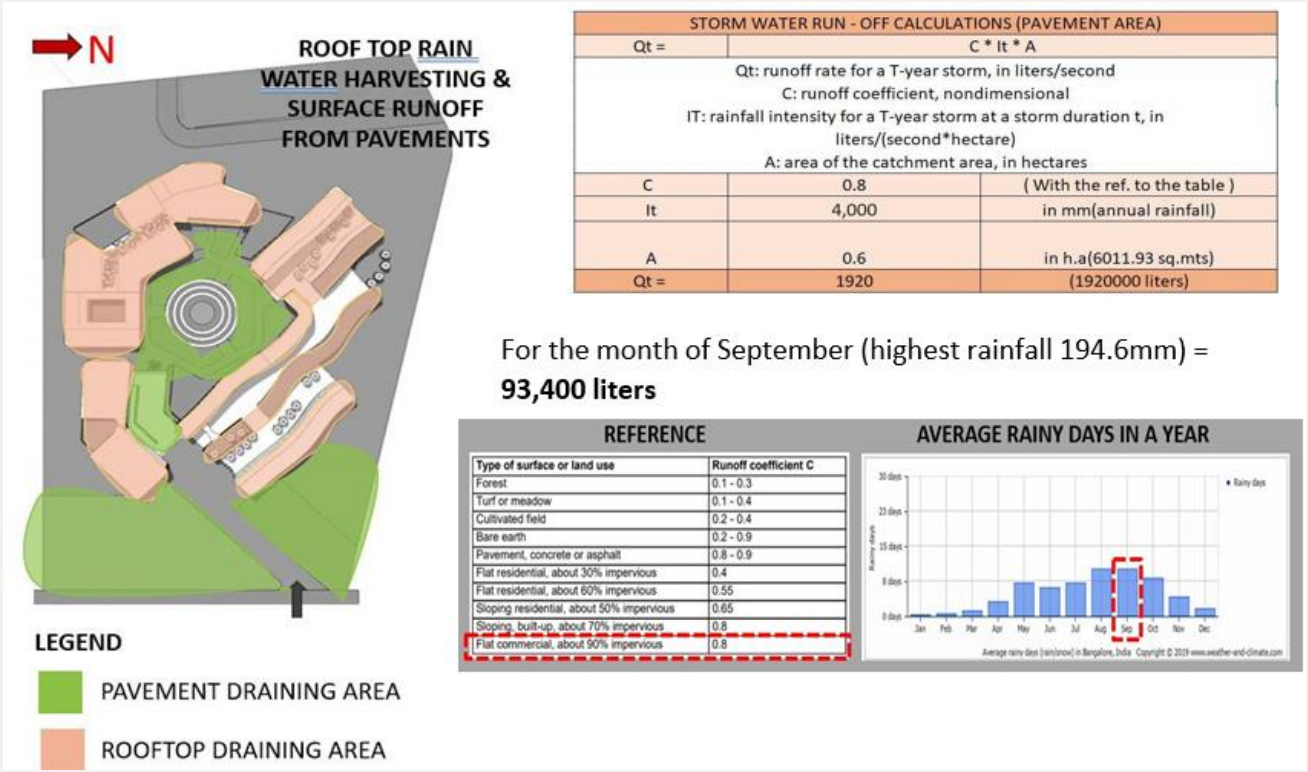
Rain Water Calculation

Rain water harvesting from canopy = Area of canopy x coefficient x annual rainfall (in mm) Area of the canopy = 1625 sq.m

Coefficient of runoff= 0.9

Annual Rainfall of Bangalore = 4000 mm

Rain water harvesting from canopy = 58,50,000 liters of potable water annually.



STORM WATER RUN - OFF CALCULATIONS (PAVEMENT AREA)		
Qt =	C * It * A	
Qt: runoff rate for a T-year storm, in liters/second C: runoff coefficient, nondimensional IT: rainfall intensity for a T-year storm at a storm duration t, in liters/(second*hectare) A: area of the catchment area, in hectares		
C	0.8	(With the ref. to the table)
It	4,000	in mm(annual rainfall)
A	0.6	in h.a(6011.93 sq.mts)
Qt =	1920	(1920000 liters)

For the month of September (highest rainfall 194.6mm) = **93,400 liters**

REFERENCE

Type of surface or land use	Runoff coefficient C
Forest	0.1 - 0.3
Turf or meadow	0.1 - 0.4
Cultivated field	0.2 - 0.4
Bare earth	0.2 - 0.9
Pavement, concrete or asphalt	0.8 - 0.9
Flat residential, about 30% impervious	0.4
Flat residential, about 60% impervious	0.55
Sloping residential, about 50% impervious	0.65
Sloping, built-up, about 70% impervious	0.8
Flat commercial, about 90% impervious	0.8

AVERAGE RAINY DAYS IN A YEAR

Waste Water Calculation

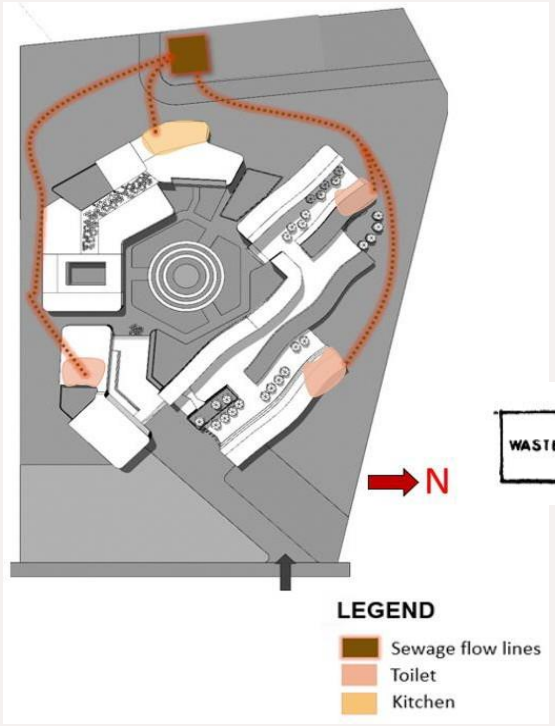
W.C = 1.28 gallons per flush

wash basin= 2 gallon/min for 20seconds= 0.67 gallons

urinals =1 gallons per flush

kitchen sink = 2.2gallons per minute

Assuming 1000 persons/day



SPACES	W.C	WASH BASIN	URINALS	TOTAL WATER PE USAGE
RETAIL	18	21	12	49.2
WORKSHOP/F.C	8	5	-	13.6
AUDITORUM/ ADMIN	6	8	5	18.04
KITCHEN SINK	2			4.4
TOTAL CONSUMPTION OF WATER				89.2 GALLONS

Waste Water Tank Capacity

(Length X width X depth in feet)/ 0.1337 = gallons

40 X 30 X 10) / 0.1337 = 89753.2 gallons

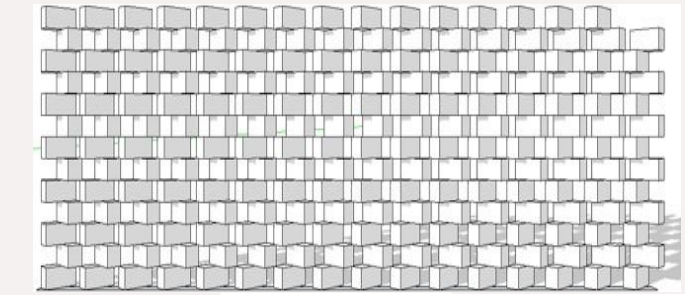
12m X 9m X 3m is the capacity of sewage tank on the site.

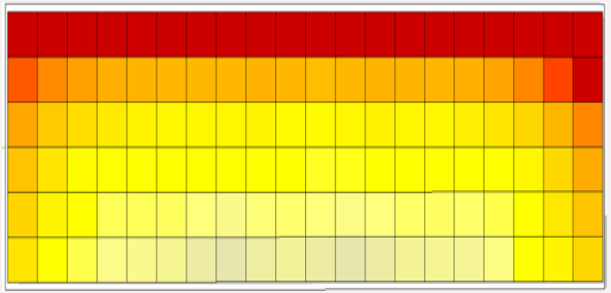
Utilizing the natural slope on the site for the drain of waste water.

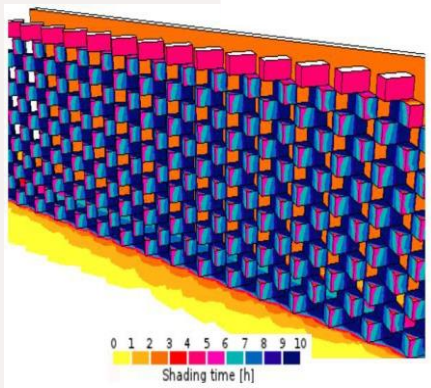
Locating sewage tank at rear would be helpful while cleaning it and not disturb the main function.

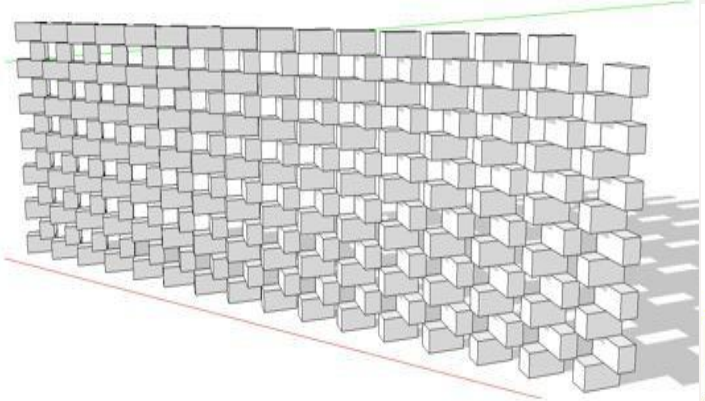
Jali Ratio For South Walls

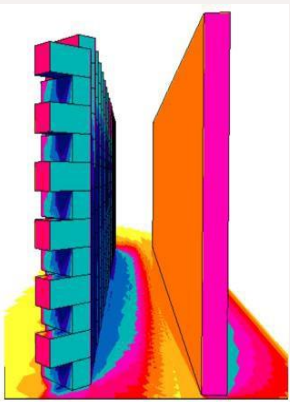
This proves that shading time of 3-6 hrs is done in floor when compared to wall of 1-2 hrs









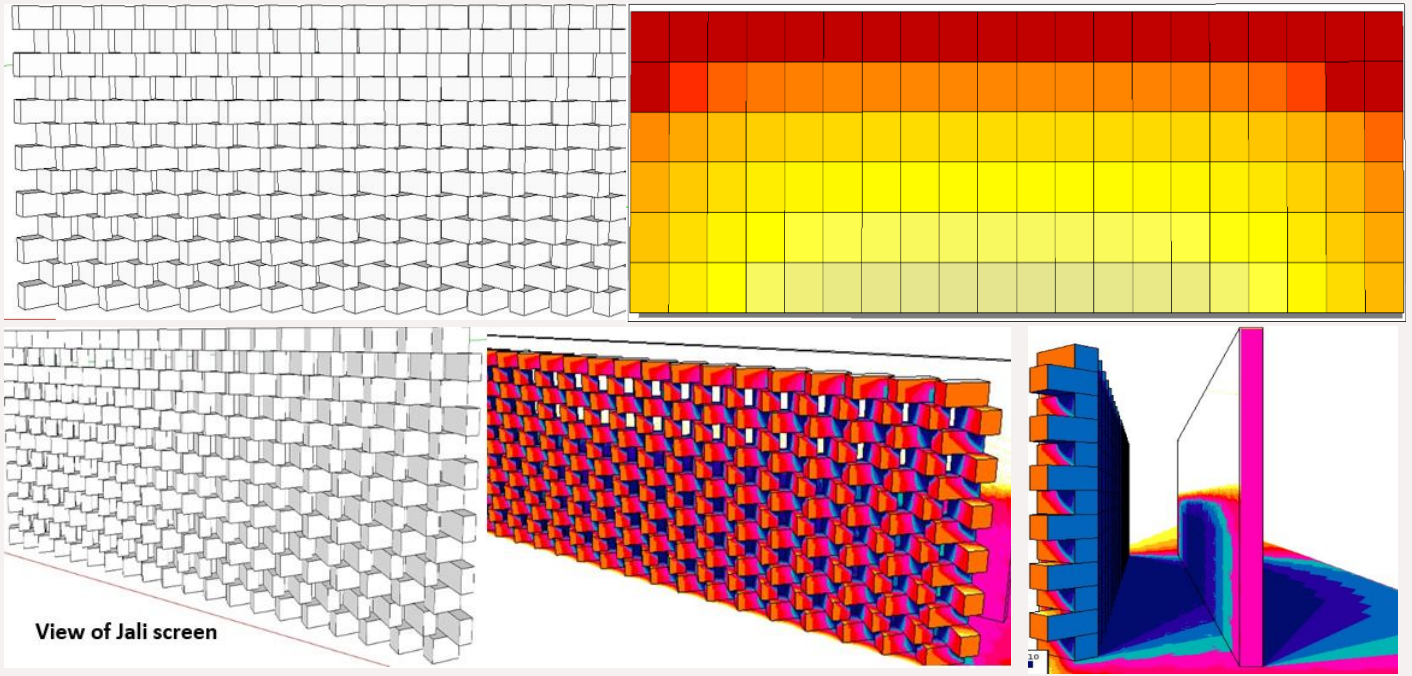


Brick size – 19" x 9" x 9", Ratio 2:1

In this case, The 19" bricks was placed at an angle of 45 degree and the void spacing is 9". By seeing the simulation results on SHADOW ANALYSIS, & SUN HOURS,30% - 50% of heat is absorbed by the adjacent wall to the maximum. So this type of jail is used in South walls to avoid sunlight and also it gives shade.

Jali Ratio For West Walls

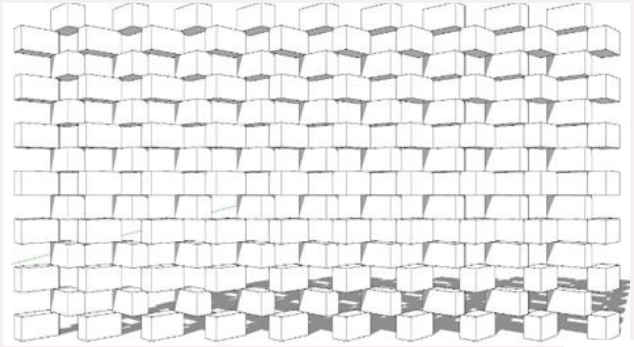
Sun Hours in a day (This is the result of shade of the wall which was placed 1.5m behind the jali screen) This proves that shading time of 8-10 hrs. is done in floor when compared to wall of 5-8 hrs.

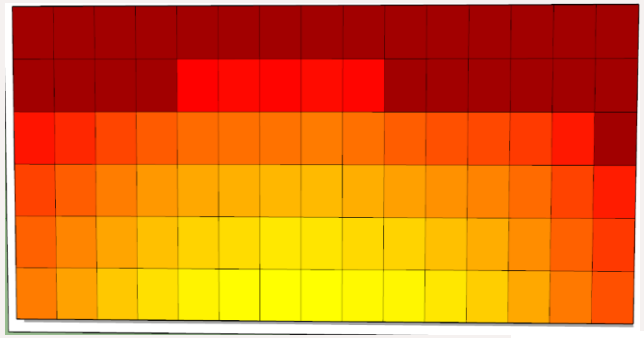


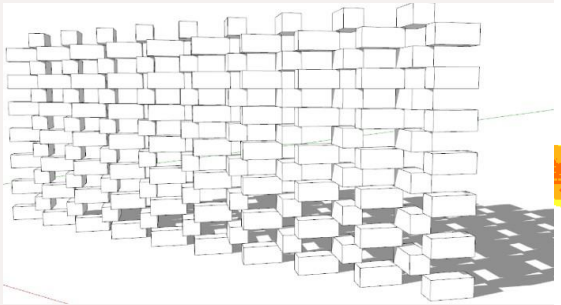
Brick size – 19" x 9" x 9", Ratio 2:0.5

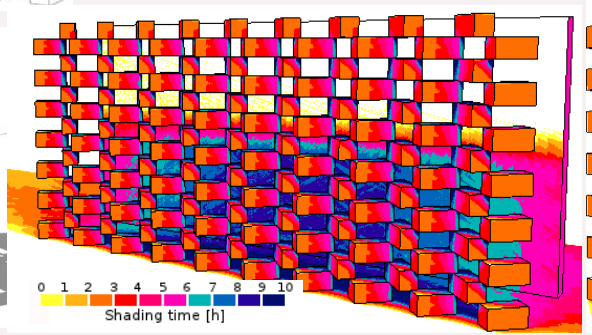
In this case, The 19" bricks was placed at an angle of 45 degree and the void spacing is 4.5". By seeing the simulation results on SHADOW ANALYSIS, & SUN HOURS, 25% - 35% of heat is absorbed by the adjacent wall to the maximum. So this type of jail is used in West walls to avoid sunlight

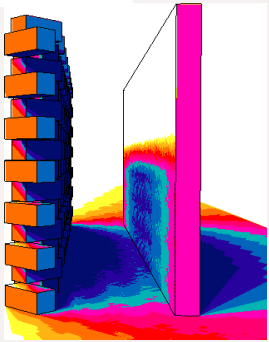
Jali Ratio For North & East Walls











This proves that shading time of 5-8 hrs. is done in floor when compared to wall of 6-7 hrs. of 5-8 hrs.

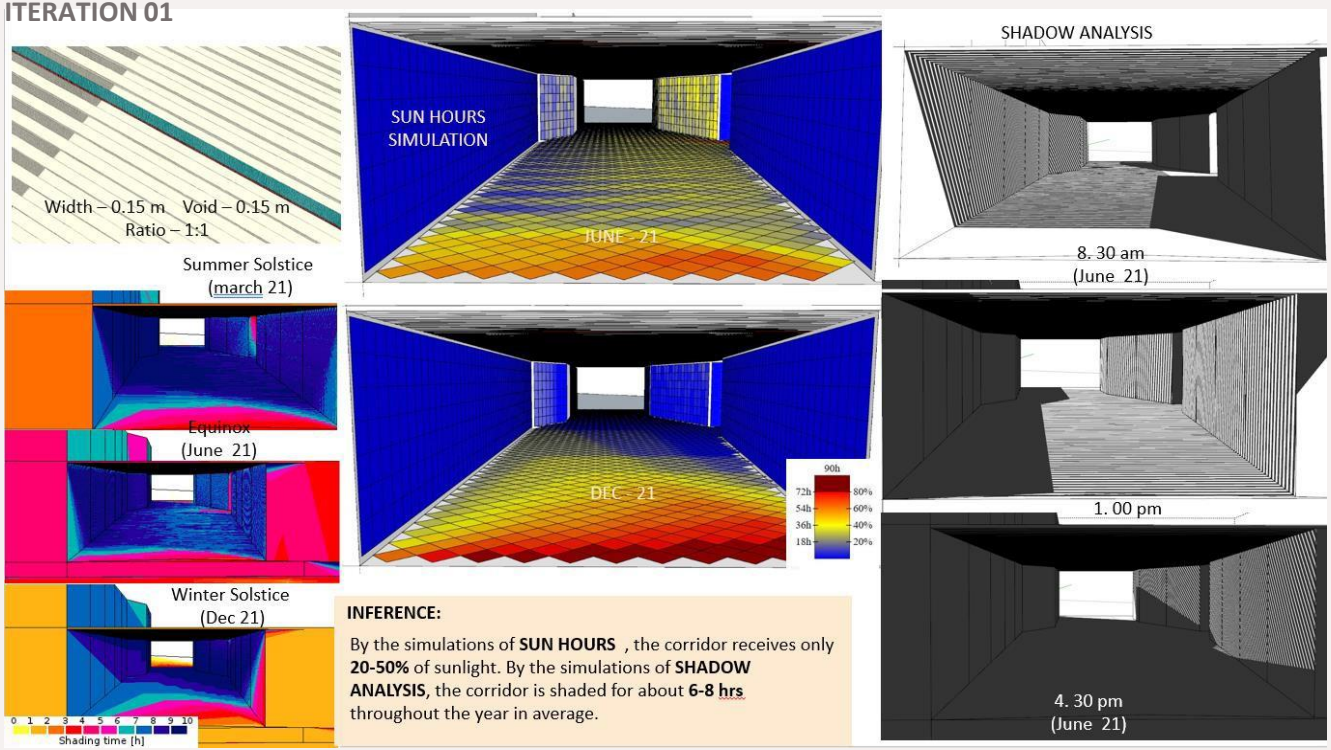
Sun Hours in a day (This is the result of shade of the wall which was placed 1.5m behind the jail screen)

Brick size – 19" x 9" x 9", Ratio 2:0.5

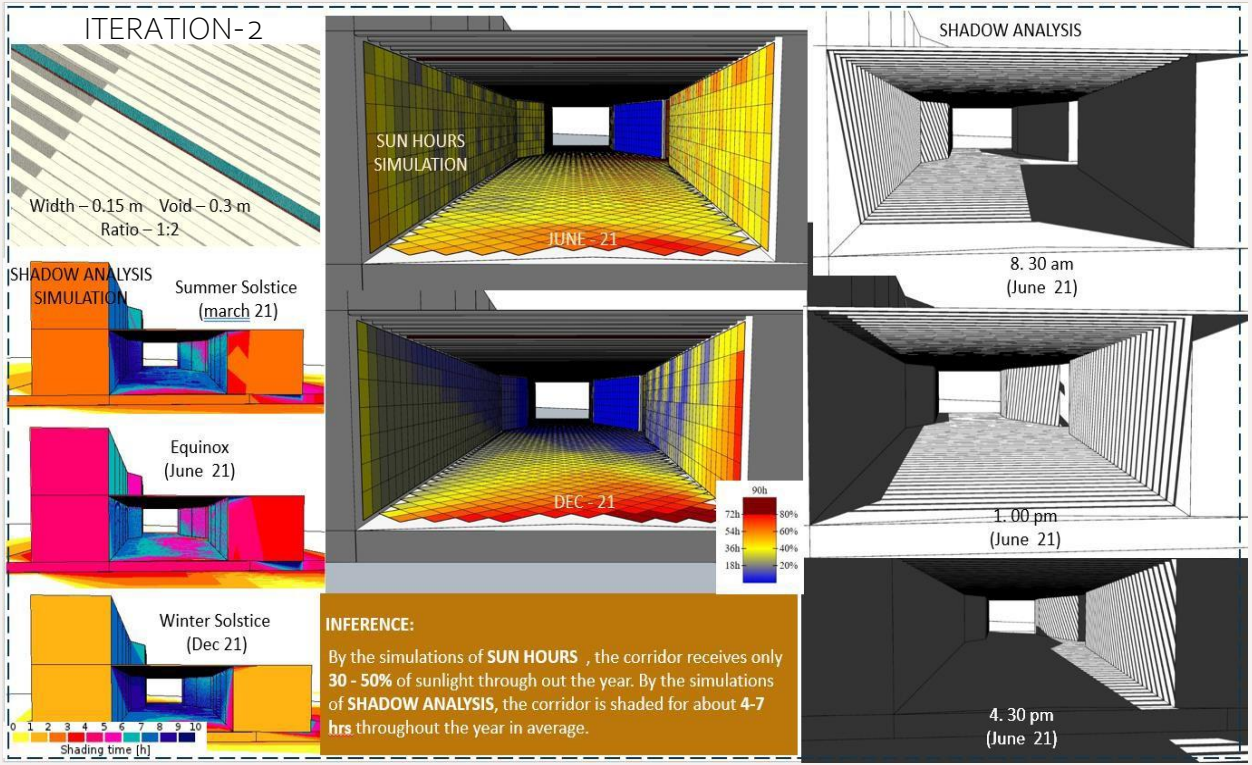
In this case, The 19" bricks was placed at an angle of 45 degree and the void spacing is 13.5". By seeing the simulation results on SHADOW ANALYSIS, & SUN HOURS, 25% -

35% of heat is absorbed by the adjacent wall to the maximum. This proves that shading

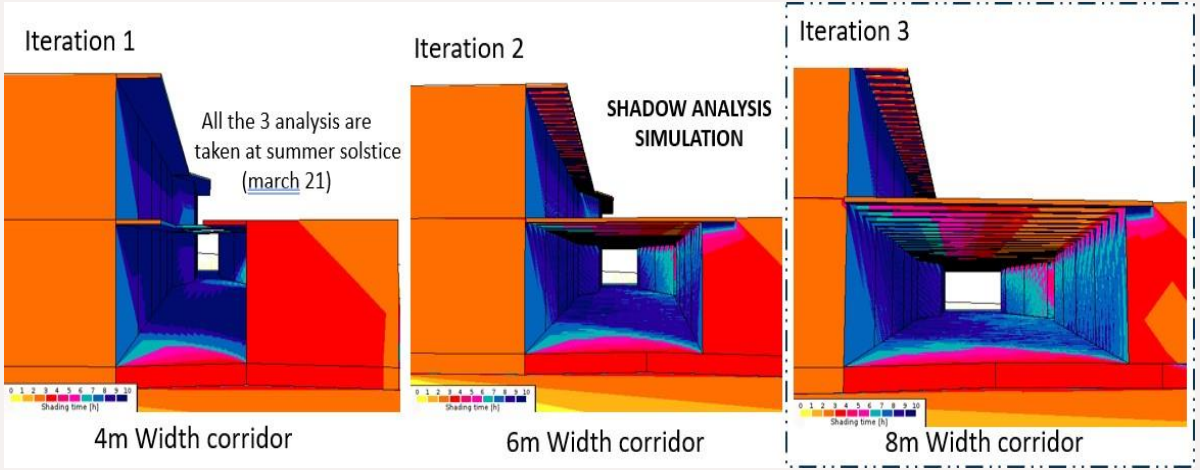
Analysis of Pergola

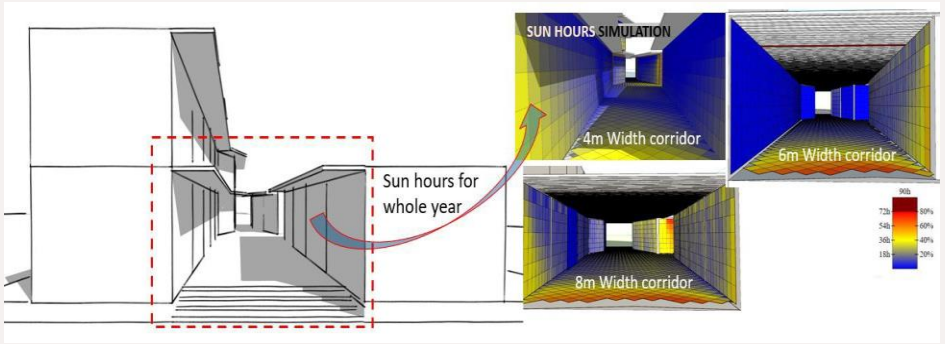


Analysis of Pergola



Analysis of CORRIDOR width





With the analysis of Sun hours , 8m corridor receives the partial daylight & shade throughout the year.

Calculations of a Green Roof & Materials

CALCULATION:

THERMAL RESISTANCE:

RT = Rsi + Rse + R1 + R2 + R3 + ...

= 0.17 + 0.04 +1.249

= 8.26 m.K/W

THERMAL CONDUCTIVITY:

K= K1+K2+K3+K4+.....

= 1.16+0.7+0.1+0.27+0.04+0.7+0.17+1.58+0.7

= 5.44 W/mK

U-VALUE CALCULATION:

Uroof = 1/ RT = 0.12 W/m.K

- This is **less** than the maximum Uroof value of 1.2 W/m.K as per ECBC.
- Hence **it does complies with the requirement.**

TIME LAG FOR WALL		
Base case		
Brick wall	230 mm	3 hrs
Cement Plastering	25 mm	0.26 hrs
Time lag	3.26 hrs	
Thickness of wall	255 mm	

TIME – LAG

TIME LAG FOR WALL		
Iteration - 3		
Brick wall	230 mm	3 hrs
Cement Plastering	25 mm	0.26 hrs
Adhesive	10mm	0.15 hrs
XPS Board	75 mm	4.5 hrs
Cement Plastering	25 mm	0.26 hrs
Exterior Finish	10mm	0.15 hrs
Time lag	8.58 hrs	
Thickness of wall	375 mm	

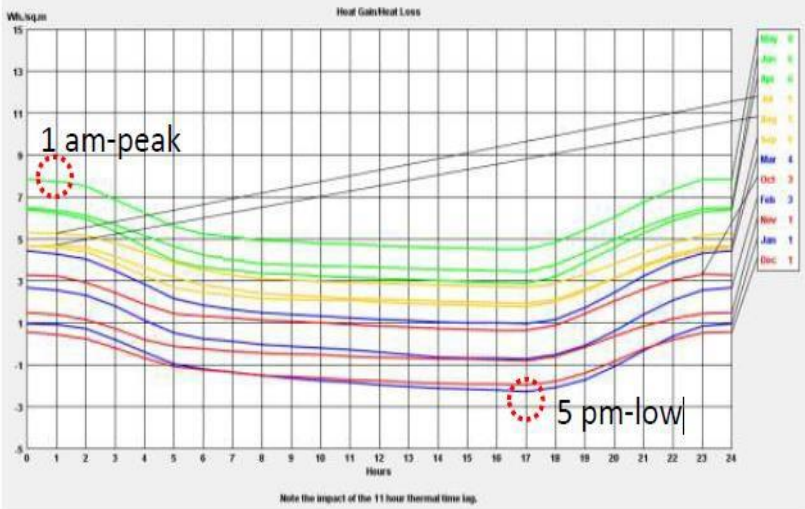
TIME LAG FOR WALL		
Iteration - 4		
Double Brick	250 mm	8 hrs
Air cavity	25 mm	1 hr
XPS Board	25 mm	1.5 hrs
Glazing	12.7mm	0.75 hrs
Adhesive	10mm	0.15 hrs
Interior Finish	10mm	0.15 hrs
Time lag	11.55 hrs	
Thickness of wall	320 mm	

GREEN - ROOF

Green Roof Construction Details			
Material Layer	**Thickness t (m)**	**Thermal Conductivity**	**Thermal Resistance**
Soil	0.1	1.16	0.09
Gravel	0.15	0.7	0.21
Permeable Geotextile	0.02	0.1	0.20
Drainage layer	0.02	0.27	0.07
Insulation	0.3	0.04	7.50
Anti root layer	0.01	OR 0.7	0.01
Waterproofing	0.01	0.17	0.06
RCC slab	0.15	1.58	0.09
Internal Plaster	0.02	0.72	0.02
Sum of all material thermal resistance			**8.26**

GREEN ROOF- HEAT LOSS	
Area	9
conductivity	5.44
Temp. Diff.	7
Thickness(inches)	30.7
Heat loss	**11.16 Btu/hr**

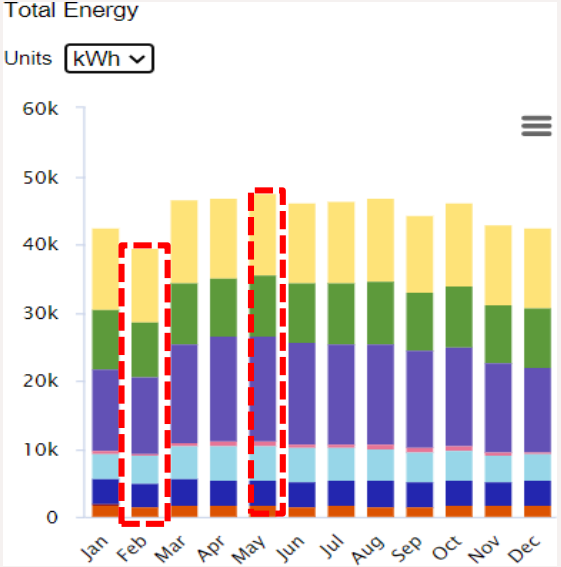
GREEN ROOF	
Area	9
U-value	0.12
Temp. Diff.	7
Heat gain	**7.56 Btu/hr**

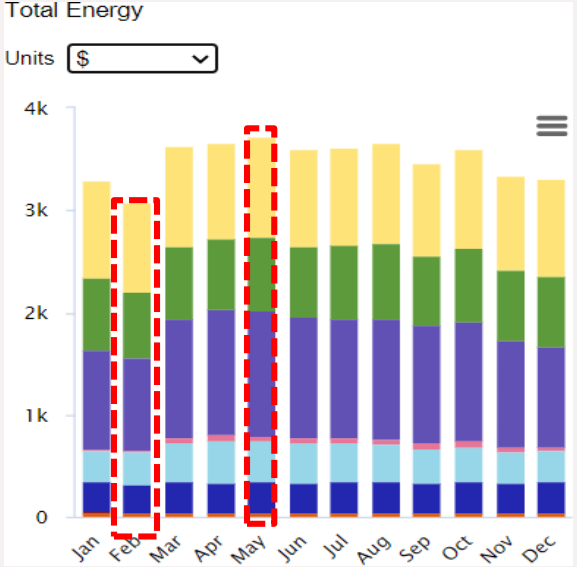


Market analysis

- Proposed case details = insulated wall with green roof, WWR of 30%.
- Orientation = 45 degree
- The energy consumption in RETAIL BLOCK annually is 517772kWh.
- Energy usage intensity = 885.3 MJ/sq.m/year

Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1]			Total Annual Energy [1]			Compare	Potential Energy Savings
				Electric	Fuel	Energy	Electric (kWh)	Fuel (Therm)	Carbon Emissions (tons)		
Weather Data: GBS_06M12_12_142080											
--	--	$0.08	$0.78	--	--	--	--	--	--		
23,611	87.0	$0.08	$0.78	$46,289	$630	$46,920	578,614	804	--		





Artificial Lighting & Orientation analysis with the reduction of Energy Consumption

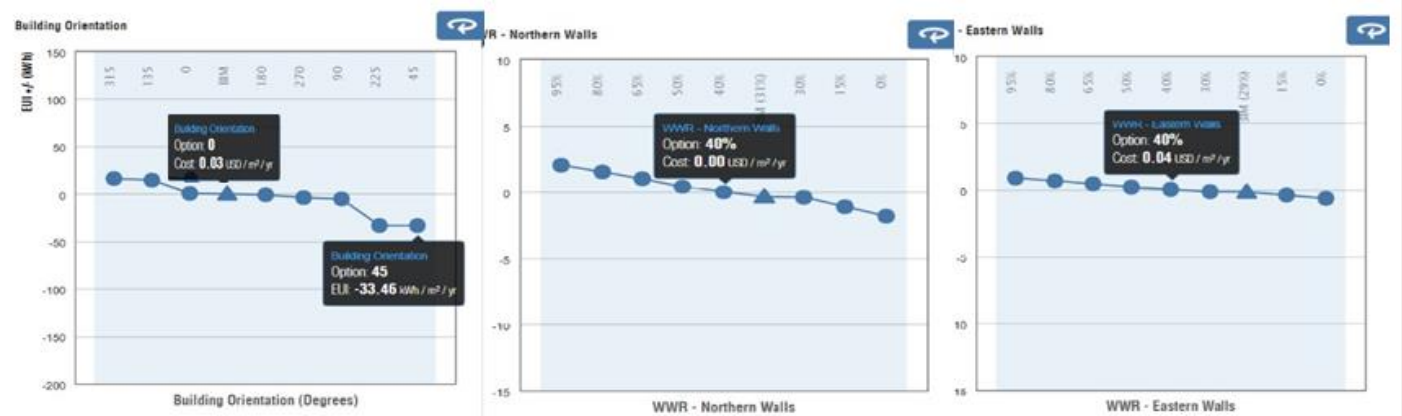


Table 7.3.1: Interior Lighting Power - Building Area Method

Building Area Type	LPD (W/m²)	Building Area Type	LPD (W/m²)
Automotive Facility	9.7	Multifamily Residential	7.5
Convention Center	12.9	Museum	11.8
Dining: Bar Lounge/Leisure	14.0	Office	10.8
Dining: Cafeteria/Fast Food	15.1	Parking Garage	3.2
Dining: Family	17.2	Performing Arts Theater	17.2
Dormitory/Hostel	10.8	Police/Fire Station	10.8
Gymnasium	11.8	Post Office/Town Hall/	11.8
Healthcare-Clinic	10.8	Religious Building	14.0
Hospital/Health Care	12.9	Retail/Mall	16.1
Hotel	10.8	School/University	12.9
Library	14.0	Sports Arena	11.8
Manufacturing Facility	14.0	Transportation	10.8
Motel	10.8	Warehouse	8.6
Motion Picture Theater	12.9	Workshop	15.1

Calculation for lighting in a single shop :
Area of a single shop – 36 sq.m
Watt required per sq.m – 16.1 LPD Total Light Power Density - Area of a
single shop x Watt required per sq.m- 36 x 16.1- 579.6 W
Max requirement for artificial lighting – Jan & Dec. Due to less amount of daylight.

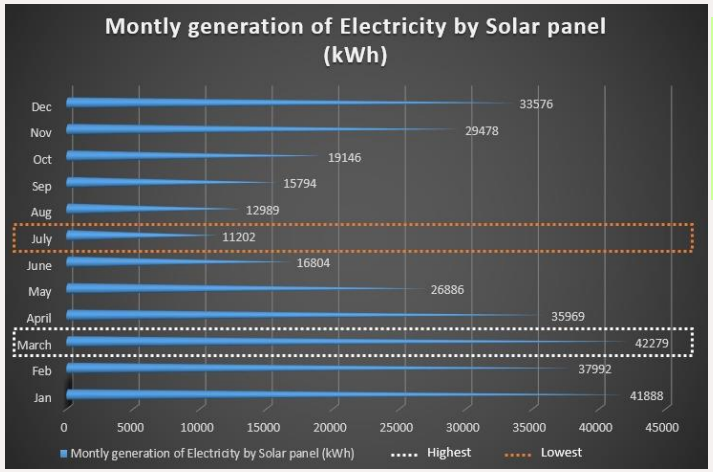
Min requirement – May. Due to sufficient daylight

Durability & Resilience – Solar Panel Calculation

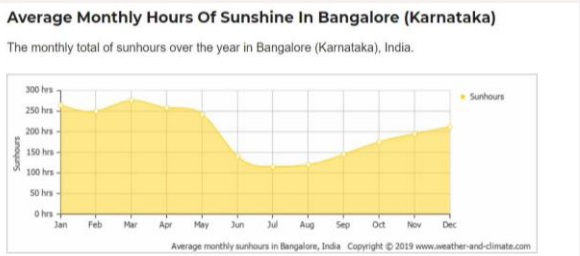
SOLAR PANEL CALCULATIONS FOR JANUARY		
Electricity produced by a single solar panel(wh per day)	110	
Actual performance of solar panel based on climatic conditions is 75%	0.75	
No. of rainy days in January	1	
Average hours of sunlight per day January	8.6	
Average hours of sunlight in January (30 days)	258	
Electricity produced by a single solar panel in January (Wh)	21285	
Dimension of single solar panel (standards for commercial purpose)	77" x 39" - 30030 sq.inch	1.93 sq.m
Total Roof area	3799.2 sq.m	
NO. of solar panels to be installed - Roof area / Area of single solar panel	1968.50	1968 panels
Total generation of electricity in the site through solar panels -Electricity produced by a single solar panel * NO. of solar panels to be installed	41888880	Wh
	41,888kWh	

SOLAR PANEL CALCULATIONS FOR JULY		
Total generation of electricity in the site through solar panels -Electricity produced by a single solar panel * NO. of solar panels to be installed	11202840	Wh
	11,202.8kWh	

SOLAR PANEL CALCULATIONS FOR MARCH		
Total generation of electricity in the site through solar panels -Electricity produced by a single solar panel * NO. of solar panels to be installed	42278544	Wh
	42,279kWh	



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Sunlight Hours/ Day	08:36	09:07	09:29	08:36	07:25	04:48	03:00	04:05	05:12	05:36	07:12	07:52	06:44
Average Daylight Hours & Minutes/ Day	11:26	11:41	12:02	12:24	12:42	12:51	12:47	12:32	12:11	11:48	11:30	11:21	12:00
Sunny & (Cloudy) Daylight Hours (%)	76 (24)	79 (21)	80 (20)	70 (30)	59 (41)	38 (62)	24 (76)	33 (67)	43 (57)	48 (52)	63 (37)	70 (30)	56 (44)
Sun altitude at solar noon on the 21st day (°).	57	66.2	77.1	88.8	82.7	79.5	82.3	88.8	77.6	66	57	53.6	72.9



SOLAR PANEL CALCULATIONS FOR DECEMBER		
Total generation of electricity in the site through solar panels -Electricity produced by a single solar panel * NO. of solar panels to be installed	33576048	Wh
	33,576kWh	

THERMAL TRANSMITTANCE OF FILLER SLAB ROOF & GREEN ROOF

TABLE 3-FILLER SLAB ROOF CONSTRUCTION DETAILS

S.No.	MATERIAL LAYER	THICKNESS (t)in m	THERMAL CONDUCTIVITY (k)	THERMAL RESISTANCE
1	Grano-flooring concrete(laid to slope)	0.05	1.8	0.03
2	Polyurethane Foam	0.09	0.02	0.0018
3	Earthern pots	0.1	0.71	0.071
4	Air space	0.09	5.88	0.5292
5	Cement plaster	0.015	0.721	0.01
6	Reinforced Concrete	0.15	1.58	0.237
7	Cement Plaster	0.015	0.721	0.011
8	Inside film			0.138
Sum of all material thermal resistance				1.02863
	Rt	Rsi+Rse+R1+R2.....	0.17+0.04+1.03	1.24 m2.K/W
	U roof	1/Rt	1/1.69	0.79 W/m2.K

RT = Rsi + Rse + R1 + R2 + R3 + ...

= 0.17 + 0.04 +1.249 = **1.69 m.K/W**

Thermal Transmittance of Roof,

Uroof = 1/ RT = **0.79 W/m.K**

This is **less** than the maximum Uroof value of 1.2 W/m.K as per ECBC. Hence **it does complies with the requirement.**

TABLE 2 – Green Roof Construction Details

Material Layer	Thickness t (m)	Thermal Conductivity	Thermal Resistance
Soil	0.1	1.16	0.09
Gravel	0.15	0.7	0.21
Permeable Geotextile	0.02	0.1	0.20
Drainage layer	0.02	0.27	0.07
Insulation	0.3	0.04	7.50
Anti root layer	0.01	OR 0.7	0.01
Waterproofing	0.01	0.17	0.06
RCC slab	0.15	1.58	0.09
Internal Plaster	0.02	0.72	0.02
Sum of all material thermal resistance			8.26

RT = Rsi + Rse + R1 + R2 + R3 + ...

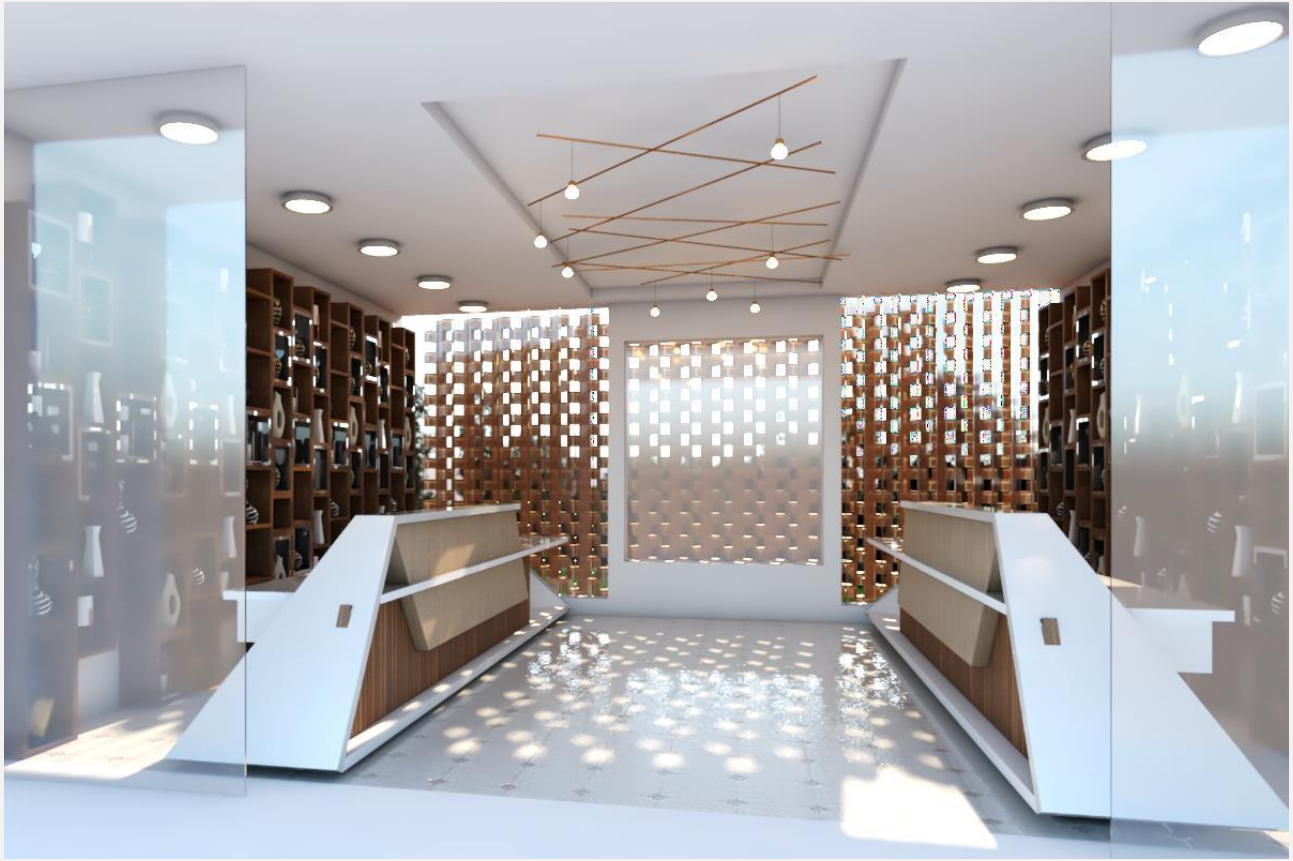
= 0.17 + 0.04 +1.249 = **8.473 m.K/W**

Thermal Transmittance of Roof,

Uroof = 1/ RT = **0.12 W/m.K**

This is **less** than the maximum Uroof value of **1.2** W/m.K as per ECBC. Hence **it does complies with the requirement.**

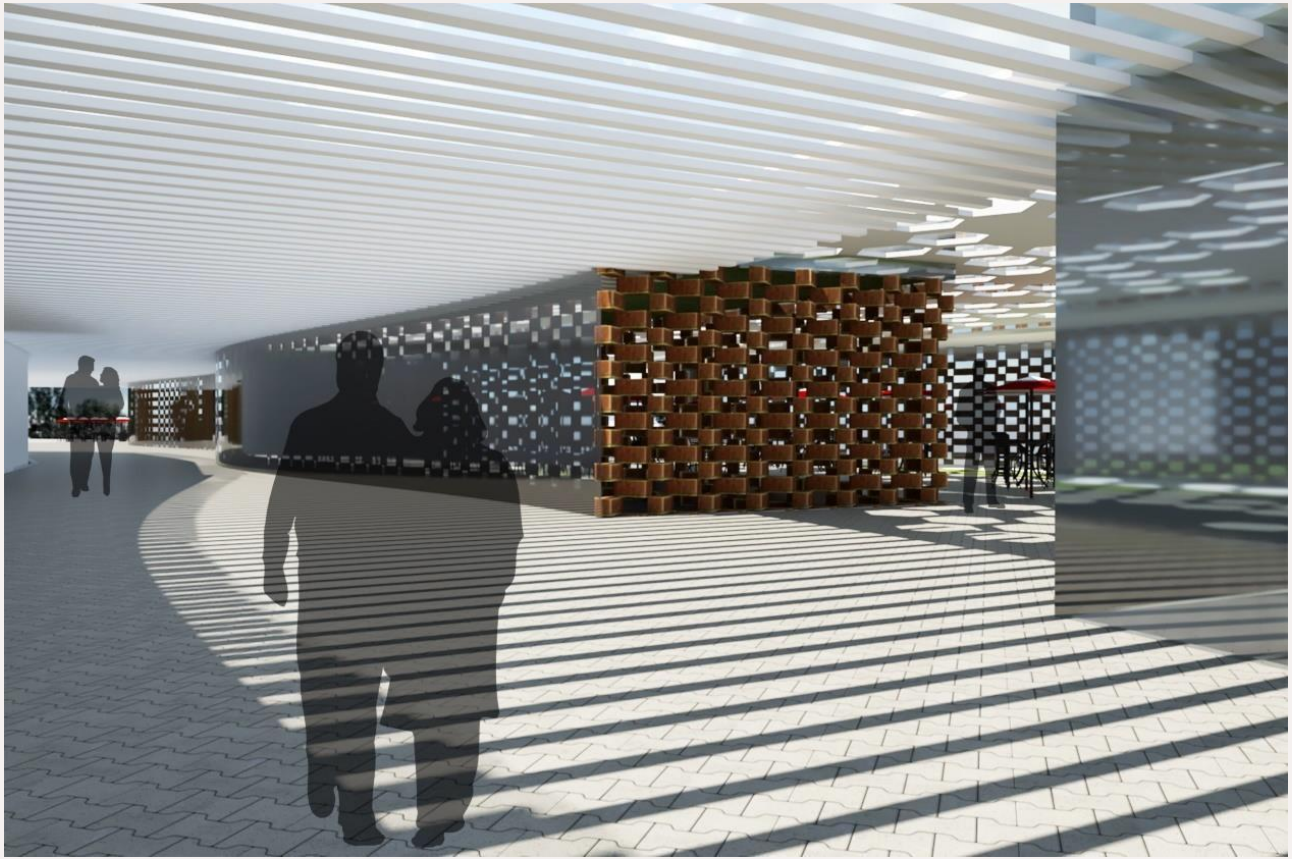
VIEW 1 – Interior view of one retail shop



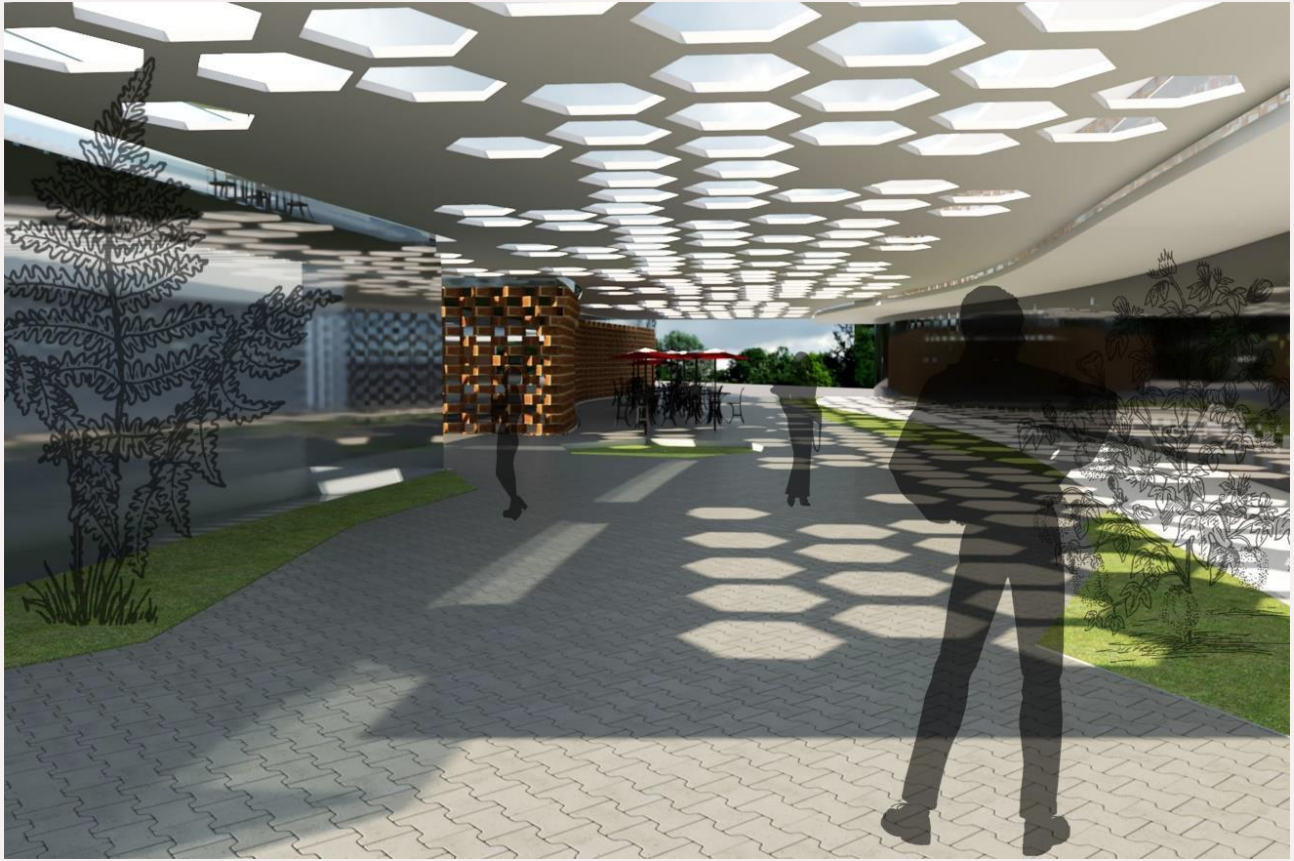
VIEW 2 – Exterior view of outdoor street shopping

VIEW 3 – Exterior view of Retail block from O.A.T

VIEW 4 – Interior view
Street Shopping view
under pergola



VIEW 5 –Entry to shopping block



VIEW 6 – View of Connecting zone between retail blocks

Thank you

For Listening & Patience